THE MURIDS AND SMALL DASYURIDS IN TASMANIA

Parts 3 and 4

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Part 3. *Pseudomys higginsi* (Trouessart)

ABSTRACT

The results of three years' (1963-1965) collecting and field observations on the long-tailed rat *P. higginsi* are recorded.

The localities from which specimens have been collected are given and the extent of distribution, based on habitat is mapped and described.

A full description, based on 68 recently collected specimens is given, together with tabulated measurements of plastic features and skulls. Notes are given on habits, activity, choice of nesting sites, the invasion of buildings, diet and faecal pellets.

Breeding has been found to be seasonal, the young being born between mid-November and mid-March with three being the usual litter. Some details are given of embryonic features and development. Three litters have been born in captivity from which the newly born young are described and growth and development detailed. Sexing by scrotal pigmentation has been found possible from an early age. Some notes are given on the occurrence and progress of sub-adult moult.

Methods of trapping, catch expectancy, damage to and predation of trapped rats and the associated small mammal species are discussed. A series of ectoparasites has been collected and some determinations are tabulated. Some results of laboratory tests for diseases are given. The influence of natural predation and the effects of fire and milling operations are discussed.

DISTRIBUTION

Pseudomys higginsi has now been collected from numerous localities in Tasmania ranging in altitude from near sea level to about 3,000 feet. All known occurrences have been in or near rainforest and its stronghold is in the extensive rainforests in the western half of the island.

In addition to the series personally collected from near Cradle Mountain and Waratah in the western highlands, and Corinna near the west coast, the Queen Victoria Museum holds specimens from Magnet, Port Davey on the south-west coast, Mount Barrow in the central north-east, and Golden Valley in the Great Western Tier. The Tasmanian Museum holds specimens from Port Davey, St. Valentine's Peak in the western highlands, Lunawanna on Bruny Island, Mount Wellington, and the Arve River in southern Tasmania. B. C. Mollison (pers. comm.) records its occurrence in the Styx and Florentine Valleys, at Lake Fenton in the central south, and in a deep wet gully at the foot of the Great Western Tier in the midlands.

Its distribution illustrated in figure 6 is based on the distribution of its preferred habitat within which are shown the location from which specimens have been collected. Much of the rainforest in western Tasmania is broken up with areas of open sedgeland. As these openings vary greatly in extent and distribution it has not been practicable to exclude them in the figure and the shading includes communities other than rainforest which occur within its overall limits. Some isolated patches of rainforest which have not been sampled are included: from experience it is to be expected that they would be inhabited by *P. higginsi*.

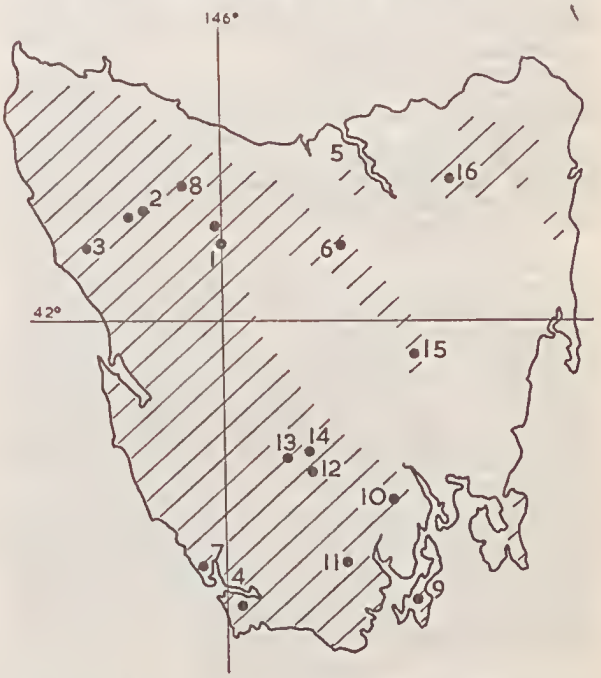

FIGURE 6.
Localities from which *P. higginsi* has been collected and the probable distribution based on habitat. Places mentioned in the text are: 1. Cradle Mountain, 2. Waratah, 3. Corinna, 4. Port Davey, 5. Flowery Gully, 6. Golden Valley, 7. Bond Bay, 8. St. Valentines Peak, 9. Lunawanna, 10. Mount Wellington, 11. Arve River, 12. Styx Valley, 13. Florentine Valley, 14. Lake Fenton, 15. Great Western Tier, 16. Mount Barrow.

The map is thus intended to show the general range only.

A once wider distribution is indicated by fragmentary skull remains among sub-fossil bone deposits in limestone caves at Flowery Gully. Trapping in the vicinity failed to produce *P. higginsi* and the habitat in the immediate neighbourhood is not consistent with that in which the rat is normally found. There is however, an area of typical rainforest a few miles to the south-west which is a fauna sanctuary where the rat probably still lives today.

HABITAT

The rainforests (see plate 8) which are the preferred habitat of *P. higginsi*, are somewhat variable and their composition is dependent on several factors. Jackson (1965) gives an explanation of these influences and discusses the various ecotonal effects. By far the largest colonies of *P. higginsi* have been found in forests dominated by *Nothofagus cunninghamii* (beech), *Atherosperma moschatum* (sassafrass), *Eucryphia lucida* (leatherwood), *Phyllocladus rhomboidalis* (celerytop pine) and *Anodopetalum biglandulosum* (horizontal scrub), but rainforests dominated by *Eucalyptus* spp. have also been found to support good populations. The under-storey may vary in density and include *Olearia argyrophylla* (musk), *Pittosporum bicolor* (cheesewood), *Drimys lanceolata* (native pepper), *Persoonia gunnii* (Gunns persoonia), *Anopterus glandulosa* (laurel) and *Dicksonia antarctica* (soft tree fern), the latter often being dominant in the gullies.

In many places, particularly in the beech-dominated rainforests, there is a heavy accumulation of decaying debris, fallen timber and rotting stumps and logs, over much of which grows a carpet of wet green moss. Such accumulations produce a labyrinth of sub-surface cavities and the decayed nature of much of the fallen timber and stumps makes additional excavation by the rats a simple matter.

To a lesser degree *P. higginsi* also occurs in the various ecotone habitats bordering the rainforests and on occasions has been trapped in the *Mesomelaena sphaerocephala* (button grass) sedgelands. It is considered that the occurrence in sedgeland is exceptional and that the individuals involved were footloose vagrants on exploratory excursions. Climatic conditions vary greatly. In the sub-alpine areas extensive winter snow falls occur with a covering up to a foot deep lying for several weeks at a time, though the dense canopy and heavy ground litter prevent local isolation. Annual rainfall exceeds 100 inches in much of the western area though in some of the isolated eastern areas it is only half this figure. Temperature likewise varies widely from minima as low as 10°F in the sub-alpine areas to maxima in the middle nineties on the lowlands. However, the sheltered nature of the micro-habitat on the floor of the rainforests no doubt forms an effective buffer to these extremes.

DESCRIPTION

The following description is based on a series of 53 skins and associated skulls and 15 spirit specimens held in the collections of the Queen Victoria Museum. Most have been collected by the author in the vicinity of Waratah, Cradle Mountain, and Corinna in 1963, 1964 and 1965, the remainder being from other places mentioned in the text, or are cage-bred individuals.

External characters

P. higginsi (see plate 9) has a lightly-built, rather delicate and long-legged appearance which is accentuated by its nervous disposition and its habit of making sudden evasive leaps. The ears are comparatively large and prominent, slightly elongated and well rounded terminally. When pressed forward they cover the eyes. The posterior basal region of the ears is well furred but the anterior and posterior surfaces of the terminal half are only sparsely covered with black hairs reaching to 1 mm. The composite effect is greyish-brown somewhat darker terminally but this varies with the angle of viewing.

The face is somewhat pointed with the eyes prominent and set well forward. When the animal is handled and frightened the eyes protrude prominently. The iris is dark brown and the pupil black. The nostrils are naked and pale flesh pink in colour, and the short hairs on the extreme tip of the nose are white. The incisor teeth are slender, the upper set being an orange colour on the anterior surface and reaching to 4 mm. above the gums, the lower set being anteriorly pale yellow and reaching to 6 mm.

The legs are comparatively long and the hind feet large with the claws sharp, well curved and almost white except for a slight pigmentation which is sometimes noticable beneath the semi-transparent surface. The dorsal surface of the feet is well covered with short white hair.

The manus is invariably white, the pads rounded, smooth and prominent. The three interdigitals are about equal in size, the two metacarpals much larger with the outer slightly exceeding the inner. The digital formula is $3 > 4 > 2 > 5 > 1$ the first being reduced and non-functional. There are usually six digital rings beneath the second, third and fourth toes and five beneath the fifth toe.

The pes is pale, the under-surface of the toes being white but a pale greyish tone becomes obvious towards the heel. The pads do not differ greatly in size but the outer metacarpal is always the smallest and is usually rounded in shape. The first and fourth interdigitals usually show a weak division near the outer edge. The digital formula $3 > 4 > 2 > 5 > 1$. The digital rings are irregularly formed in the basal region but generally number eight to nine on the second, third and fourth toe, seven to eight on the fifth toe and four on the first toe.

The tail is longer than the head and body but will easily strip with the result that individuals are sometimes found with reduced tails. The complete tail is slender and finely tapered and is often carried in a posteriorly directed crescent, well clear of the ground (see plate 9). The tail scales are indistinct, of a white colour, and are arranged in about 220 rings which contain up to 20 scales in the basal region but become progressively reduced distally. The tail is sparsely covered with fine bristle-like hairs which are arranged in single concentric circles erupting between the tail rings. The hairs in each ring are evenly-spaced, shortest in the basal region where they reach to about 2 mm, and longest distally where they may reach to 6 mm. They are brown dorsally and white ventrally; the separation being very distinct. Odd individuals may have the entire tail-tip white for a length of up to 15 mm.

There are four nipples situated inguinally as in all pseudomyine rats (see figure 7). The vagina is normally closed. The scrotum becomes more prominent with the approach of the breeding season and may attain a size of 25 by 16 mm. It is well furred except for the posterior end which is nearly naked and in which the skin possesses a slight greyish pigmentation.

Pelage

Sexual dimorphism is not apparent in the pelage. The fur is soft, dense and somewhat fluffy in appearance. It is longest on the rump where it may reach to 25 mm.

in some individuals but is reduced to 15 mm. on the neck and flanks and 10 mm. on the cheeks, mid-head and belly. The guard hairs are inconspicuous and reach to about 10 mm. above the main pile on the back and flanks but on the belly they barely exceed the main pile. They are most numerous on the back where they are a lustrous black for the entire length. On the flanks the tip may be a sandy grey and on the belly, pale grey or white. They taper terminally to a very fine tip.

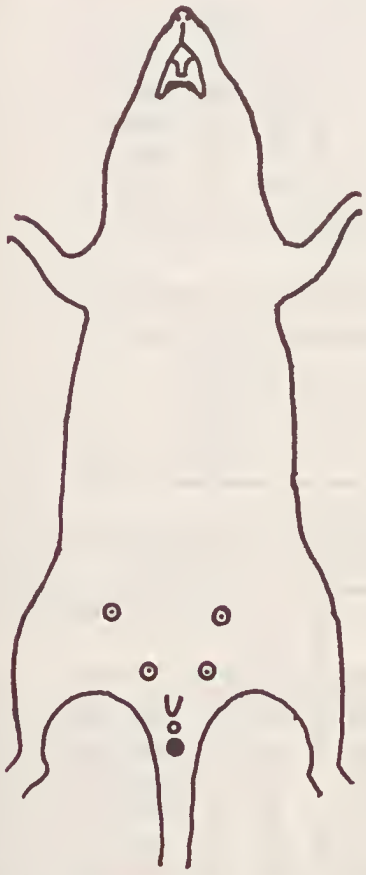

FIGURE 7. Mammary pattern of *P. higginsi*.

The main body pile is a soft leaden grey for the greater part of its length being slightly paler on the belly. The terminal region on the dorsum is a pale sandy yellow, becoming paler on the flanks, and pale grey to white on the ventrum. The composite effect is a greyish brown, being darkest on the back and merging to a pale grey on the belly. The intensity of shading varies with the angle of viewing. The pelage colour on the head and legs is generally similar to that of the body except for the region round the lips where it fades to a pale grey. There is little variation between individual adults but sub-adults in juvenile pelage lack the sandy brown shading and are a more uniform grey.

The mystacial vibrissae are prominent and tapered over their entire length to a very fine tip. They are generally a lustrous black for the greater part of their length but most change terminally to a pale grey or white. A few are white for their entire length, especially the short anterior members. The posterior members are longest and may reach to 65 mm. The anterior members are abruptly shorter and may be as little as 10 mm.

Other vibrissae are not easily discernible but usually there is a single genal reaching to 25 mm., one or two supraorbitals to 35 mm., an interramal to 10 mm. and two ulnacarpals to 10 mm.

Plastic dimensions

Plastic measurements were taken as described in part 2 of this series, and the statistical details given in table 9 are based only on individuals taken in the course of the study and measured by the author. Sub-adults of less than 50 gm. have been excluded.

The heaviest and largest rat collected was a female taken on 27.VI.1963. She had a body weight of 89 gm. and a head and body length of 145 mm. By comparison, the heaviest male recorded was a rat which had been held in captivity for two years. At death, on 27.II.1967, it was found to weigh 82 gm. and to be carrying heavy fat deposits. The heaviest male taken in the wild was collected on 27.VI.1963. It weighed 77 gm. and had a head and body length of 133 mm. This size predominance in favour of females is also illustrated in table 9 which shows that the mean measurements of females slightly exceed those of males in all dimensions except pes length.

The smallest rat collected for processing was a sub-adult female taken on 10.II.1965. It weighed 43 gm. and had a total length of 274 mm. and a head and body length of 113 mm.

The length of the tail, ear and pes when expressed as a percentage of the head and body length (see table 10) gives an indication of the relative proportions of the animals but does not indicate any significant sexual dimorphism.

Skull

The measurements given in table 11 were made on a series of 49 skulls and were taken in the same manner as illustrated in part 2 of this series. Sub-adults of less than 50 gm. have been excluded. Damage resulting from the use of snap traps has reduced the sample size in some instances. The skull of *P. higginsi* (see plates 10 and 11) is finely sculptured and of a rather fragile appearance in comparison to other rats of similar size. The cranium is well rounded and lacks a well defined supraorbital ridge. Table 11 indicates that the skulls of males are slightly longer than those of females though the difference is so small as to be of little significance. The molar teeth are relatively small, the cusps of sub-adults being short but prominent. Molar wear becomes noticable in sub-adults of 50 gm. and increases with the age of the rat. Some adults exhibit extensive molar wear though in no instance was this found to be greatly excessive. The lower incisors are tapered to a fine chisel point, the tapering being evident for almost the entire length of the exposed posterior surface of the teeth. The upper incisors are stout and the posterior tapering is much less acute. No instance of malformation or decay was evident.

HABITS

P. higginsi is primarily a nocturnal rat but odd individuals may occasionally be active in the daytime. Its favoured environment is the forest floor where it makes good use of accumulated debris as cover during its excursions. It is an accomplished climber and in captivity has been observed to run along the underside

of dry dressed hardwood battens supporting the roof lining of its cage. Despite these accomplishments it has not been found to ascend trees, preferring to limit its arboreal activities to running along the logs and branches which form part of the litter, and which may facilitate its movements from point to point.

Observations conducted by the use of a spotlight on both caged and wild rats have shown it to be exceedingly active and inquisitive. When necessary, it can move with great swiftness and if suddenly alarmed will often initiate its escape by an explosive leap of a foot or more in any direction. The long tail is apparently

TABLE 9. Weights (gm.) and measurements (mm.) of *P. higginsi*. Quotations show the number in sample, extremes and the mean in brackets.

	Males	Females
Weight	29: 50 - 82 (65.0)	26: 50 - 89 (68.6)
Total length	23:264 - 326 (300.1)	16:282 - 334 (302.7)
Tail	23:146 - 199 (169.7)	16:160 - 195 (170.8)
Head and body	29:115 - 142 (131.1)	26:120 - 145 (131.7)
Ear	29: 22 - 25 (23.4)	26: 21 - 26 (24.2)
Pes	29: 32 - 36 (33.7)	26: 31 - 35 (33.2)

TABLE 10. Length of tail, ear and pes of *P. higginsi* expressed as a percentage of the head and body length.

	Males	Females
Tail	129.4	129.7
Ear	17.8	18.4
Pes	25.7	26.2

TABLE 11. Comparisons (in mm.) of skulls of males and females of *P. higginsi*. Rats of less than 50 gm. body weight have been excluded.

	26 Males			23 Females		
	No. Sampled	Range	Mean	No. Sampled	Range	Mean
1. Total length	21	31.7 - 36.7	35.0	20	32.4 - 36.4	34.7
2. Condylo-basal length	22	28.5 - 33.3	31.7	21	30.0 - 32.8	31.3
3. Basal length	23	26.2 - 30.7	29.2	22	26.6 - 30.2	28.8
4. Zygomatic width	24	15.5 - 18.2	17.1	18	16.2 - 17.8	16.9
5. Inter-orbital width	26	4.0 - 5.1	4.6	23	4.3 - 5.0	4.6
6. Inter-parietal length	21	4.2 - 5.5	4.9	21	4.5 - 5.6	5.0
7. Inter-parietal width	21	9.5 - 11.5	10.4	21	9.4 - 11.7	10.5
8. Cranium width	23	14.2 - 15.3	14.7	21	14.2 - 15.7	14.8
9. Mastoid width	22	13.7 - 15.0	14.3	18	13.7 - 15.3	14.4
10. Nasal length	25	12.3 - 14.5	13.5	22	12.4 - 14.6	13.2
11. Nasal width	25	3.3 - 4.3	3.6	22	3.3 - 3.9	3.7
12. Palatal length	26	16.1 - 19.4	17.8	22	16.4 - 19.0	17.5
13. Palatal foramen length	26	6.0 - 7.5	6.8	23	6.2 - 7.4	6.7
14. Palatal foramen width	26	1.2 - 2.0	1.6	23	1.5 - 2.2	1.7
15. Width inside M^1-M^1	26	2.3 - 3.1	2.8	23	2.4 - 3.2	2.8
16. Width outside M^1-M^1	26	5.1 - 7.3	6.8	23	6.3 - 7.3	6.8
17. Bulla length	23	4.6 - 5.6	5.2	20	5.0 - 5.5	5.2
18. Length crowns M^1-M^3	26	4.6 - 5.9	5.2	22	5.0 - 5.7	5.4
19. Length alveoli M^1-M^3	26	5.3 - 6.3	5.7	23	5.4 - 6.5	5.9
20. Length crowns M^1-M^2	26	3.6 - 4.2	3.9	23	3.5 - 4.3	4.0

not used in a prehensile manner and is often carried well clear of the ground in a gentle downward curve. This is particularly noticeable when the rat is alarmed. When relaxed it will often sit in a semi-upright position, the forepaws held in a kangaroo-like manner. Under captive conditions it has been found to be dominated by the slower though more aggresive *R. l. velutinus* with which it shares the habitat but avoids contact whenever possible. A faint high-pitched whisper-whistle, almost inaudible to the human ear, can often be heard uttered by caged individuals and it appears to be used as a form of communication. It freely invades human dwellings and at Waldheim in the Cradle Mountain-Lake St. Clair reserve it is a regular nocturnal visitor to the camps and huts situated in the shelter of the forest. Under such circumstances it is a minor pest as it climbs onto tables and feeds on almost any available food items and generally upsets the tourist, who might be disturbed by its presence. If disturbed it will retreat by the way it entered and if circumstances permit will soon return to continue its exploration for food. When so engaged it is usually oblivious to the effects of a spotlight with the aid of which it can be approached and caught by hand. D. King (pers. comm.) has found it nests in wall cavities at Port Davey.

Muddy situations are avoided whenever possible. It has never been known to enter water of its own free will and if forced to do so it swims weakly with the head held well up. Foot beats are rapid and progress slow and it quickly tires. Its natural retreats or nesting places are in holes in the rotting stumps, logs and litter on the forest floor. In many places these sites are heavily overgrown with green moss or covered with an accumulation of fallen leaves. As this rat does not form well defined runways, the entrances to such retreats are often inconspicuous. Though it is capable of gnawing when circumstances necessitate, it gnaws much less frequently than *R. l. velutinus* or *M. fuscus*. Consequently the presence of *P. higginsi* is usually more difficult to detect.

Diet

The natural food of *P. higginsi* is not easily determined. Stomach contents are finely masticated and in every instance have consisted of vegetable matter. This has been found to be variable in colour ranging from green, cream, grey and yellow to brown and black, a feature which indicates a variety of food items. In no instance have insect remains been found in stomach contents but caged rats have been observed to take insects and spiders at every opportunity. Moths of a body length of from 10 mm. to 60 mm. and a wing span of up to 130 mm. have been fed to *P. higginsi* experimentally. These were quickly seized with the mouth, following which they were held clear of the ground with the front feet, with the rat sitting in a semi-upright position. The body parts were eaten for preference, the wings and legs usually being discarded. Large moths were sometimes only partly eaten, the still-living remains being left and consumed later. Squabbling for possession of a single moth was a common occurrence though at times several rats would feed together on a large specimen. Spiders and small lizards were similarly eaten when introduced to the cage. A wide range of vegetable items including green grass and clover clippings, apples, pears, carrots, seeds of various fruits, cabbage and lettuce leaves, commercial animal cubes, and bread have been eaten by caged individuals.

Cage studies have shown that *P. higginsi* drinks liberally when water is available but is capable of living for extended periods without access to free water provided it can obtain succulent food items. Its natural habitat is usually wet for the greater part of the year but extensive areas may lack free water during the dry summer months when it is necessary for the rats within these areas to obtain moisture from other sources.

P. higginsi defaecates and urinates indiscriminately but because it does not produce well defined runways faecal pellets are not easily located. They can usually be distinguished from those of the associated *R. l. velutinus* by their smaller size of 8 to 10 mm. by 4 to 5 mm. in diameter, and in being composed of more finely comminuted vegetable material.

BREEDING

In the wild

The breeding of *P. higginsi* is confined to a summer season. Scrotal development is not obvious outside the breeding season and testes are then carried inguinally. Testes of sub-adult males are usually about 5 x 3 mm. during the winter months and those of adults are about 12 x 5 mm. With the approach of summer and the onset of breeding, testes size increases and may reach as much as 20 x 11 mm. They then descend into the scrotum which also becomes enlarged and conspicuous. Testes contraction and retraction occurs after the breeding season.

Three pregnant females have been collected in the course of the study in the months of November, December and February (see table 12). One lactating female was collected on 24th February. Six females collected in the month of October and one collected on 9th November showed no indications of pregnancy. B. C. Mollison (pers. comm.) observed the birth of a litter of three on 26th November. These data, together with cage studies and the size of sub-adults collected during the autumn and winter, indicate that the birth of young is restricted to the four-month period from mid-November to mid-March, with three being the usual litter, produced in either or both uterine horns.

Nipples are difficult to discern in sub-adults but they become progressively more obvious with lactation and suckling when some fur loss occurs over a radius of 5 mm. from the nipples. When large young are suckling, the nipples in the normal position may be 5 mm. long and 5 mm. diameter at their base, but if distended may reach to a length of 12 mm. At this stage of lactation the tips of the nipples become dark pink, and with care milk can be expressed with the fingers.

TABLE 12. Analysis of three sets of embryos from wild caught *P. higginsi*.

Date	Crown-rump length (mm.)	Number	Uterine Horn		Registered Number
			Left	Right	
24.II.1964	30	4	4	0	1964.1.29
6.XII.1964	6	3	1	2	1964.1.317
13.XI.1965	13	3	0	3	1965.1.254

In captivity

Studies of captives commenced on 6.II.1965 when three males and one female were collected alive near Renison Bell. As they were taken in relatively close proximity to each other it was assumed that one of the males may have been mated with the female. In an attempt to prove this each male was individually introduced into the small cage in which the female was held. The first combination produced an immediate and violent reaction on the part of both animals. Offensive and evasive behaviour was undertaken by both rats as opportunity permitted and initial incompatibility was obvious. A second male produced a similar reaction. When the third male was introduced there was an immediate violent reaction with both rats leaping all over the cage for several seconds. This was followed by a period of quiet as each surveyed the other. They then carefully approached each other and a faint high pitched whisper-whistle was uttered. It is assumed that these two were a mated pair, and after mutual recognition was established the rats nuzzled the fur of each other and huddled close together in the corner of the cage.

The female did not appear to be pregnant or lactating, nor did she show evidence of having bred in that season. The pair were subsequently held in an 10 x 10 x 12 inches cage, as previously described in part 2 of this series, until 15.XI.1965. They were then released into a larger cage measuring 15 feet long by 12 feet wide by 6 feet high which was shared with several *R. l. velutinus* and a pair of sugar gliders *Petaurus breviceps*. Until this time they had shown no indication of breeding though a well-formed domed nest was always maintained and occupied in the corner of the cage.

Subsequent to their release in the larger premises they alternated their diurnally-occupied nests between several sites. These were usually in tin nest boxes measuring 6 x 5 x 5 inches which had been placed at intervals around the walls of the cage and at varying heights from the floor. The nests were formed of straw, shredded into fine fibrous strands by the rats, and packed into the nest boxes so as to form a dense lining, leaving only sufficient room for occupancy. Both rats were invariably found together and they usually blocked the entrance hole from the inside by stuffing it with nesting material. A variety of food items was always available and usually included bread, green vegetables or lawn clippings, commercial dog cubes and occasionally some fruit.

On 11.I.1966 at 0800 hours, the pair were found to be occupying a nest box near the roof of the cage. Upon inspection the male flushed from the nest and young could be heard squeaking. The nest box was removed to a work bench where upon the female flushed and examination revealed three newly born young. The nest was replaced in its original site and the female returned to settle with the young within three minutes. The male was caught and removed from the cage. The following day the nest box, with female and young, was placed in a small breeding cage (previously described) where they were held until 23.II.1966. The female was then removed and liberated in the large cage with the male. The following morning, both adult rats were found occupying the same nest box. About a month later the three young were also released into the large cage and were found to reassociate with their parents and share the same nest. Two of the offspring died in the following six months, probably as a result of fighting with *R. l. velutinus*.

On 13.XII.1966 faint squeaks were heard in an elevated nest box and the original female was found to have produced a litter of two which were then about one day old. Together with her in the nest were the original male and the surviving female offspring of the previous season, then aged about 11 months. All five rats were removed to a small holding cage (previously described) and kept together for the next 18 days. Over this period all continued to thrive and live together without any evidence of animosity. The male and young female played no part in tending the young. On 31.XII.1966, when the juveniles were showing signs of independence, the old male and young female were removed to the large cage leaving the old female with the two offspring of the second litter.

On 29.I.1967, 47 days after the birth of the second litter and 29 days after removal of the male, the old female was found to have produced a litter of four, some time within the previous twelve hours. The two young of the second litter continued to share the maternal nest with their parent and the new offspring, apparently in complete harmony. The parent often nuzzled and licked the young while they were fastened to the nipple and on several occasions the two older young, then about 50 days old, were seen to join their mother in this act as if assisting in the care and attention of the new litter. On the evening of 8.II.1967, when the third litter was 10 days old, the parent was seen to leave them in the nest and to feed and roam about the cage with her two older young. When disturbed by human presence she immediately returned to the nest, sat over the young and activated them to fasten to the nipples, as if to afford protection or to prepare for their removal should danger threaten. (The method of transport is described later).

On a number of occasions, after removal for measuring, the young were carefully handed back to the parent and held about three inches from her nose. On each occasion she readily reached out, seized it in her mouth and immediately placed it beneath her body, often pummelling it excitedly with her paws and nose and turning it on its back as if to hasten its attachment to the nipple. This was usually achieved within a few seconds following which she sat over the young in the manner of a broody hen on her chickens.

The actual birth of young was not witnessed by the author but B. C. Mollison (pers. comm.) observed the birth of a litter from a newly captured *P. higginsi*, the three young being expelled rump first, in a few seconds.

On 22.II.1967 all were transferred to larger quarters together with the old male and the surviving young of the first litter. Two days later the study was disrupted by the loss of six of the rats apparently as a result of abnormally hot weather. Despite the provision of shade and a quantity of dry straw, beneath which the rats formed tunnels, the only survivors were two of the third litter and one of the second. At this date the two youngest were 26 days old and, together, with the other survivor, have since been reared to maturity. The two parents had been held in captivity for just over two years.

DESCRIPTION, GROWTH AND DEVELOPMENT OF YOUNG

The embryo

Three females have been trapped in an obviously pregnant condition and their embryos preserved (see table 12). In registered number 1964.1.317, collected on 6.XII.1964, the embryos were contained within sperical sacs, averaging about 9 mm. in diameter. They were of a crown-rump length of 6 mm. and lacked obvious

detail. The back was strongly arched with the facial region turned under the body, and the legs appearing as mere buds.

In registered number 1965.1.254, collected on 13.XI.1965, the sacs in which the embryos were contained were slightly oval, averaging about 16 x 12 mm. The embryos were of a crown-rump length of 13 mm. and showed considerable detail. The region of the neck was strongly arched with the nose between the hind feet. The eyes were slightly elevated above the surrounding skin and possessed a dark circle of pigmentation. The ears were well formed with the pinnae turned down but free from any adherence to the basal portion. The toes appeared as elongated buds but lacked any evidence of claws. Pads were noticable on the pes and manus. The facial region was well detailed, the mouth being open with the tongue free and prominent. The tail was 8 mm. long, tapering to a fine tip. It was turned ventrally towards the head and reached to the eyes.

In registered number 1964.1.29, collected on 24.II.1964, the embryonic sacs were an oval shape averaging about 30 x 18 mm. The embryos were of a crown-rump length of 30 mm. and though the skin was still pale they were showing a slightly dark subcutaneous pigmentation. The strong arch of the neck region so prominent in the less developed embryos was now greatly reduced and the facial region rested forward of the front feet.

The eyes were still closed and protected by well formed lids. The ear pinnae were turned down for a length of 2 mm. and were adhering to the basal region. The toes were well formed and the claws obvious. The pes measured 6.5 mm. The head was rounded and the nose short. The nostrils were closed but their position was well defined. The mouth radiated 2.5 mm. from the mid-line and there was no evidence of tooth eruption. Colourless mystacial vibrissae had erupted to a length of 1 mm. and supraorbital, genal and interramal vibrissae had erupted to a lesser degree. The tail tapered to 15 mm. and faint scale rings were noticeable to the naked eye. The skin was loose and wrinkled, particularly in the region of the legs, and no body pelage had erupted.

Description of newly born young

P. higginsi has precocious young which are relatively large and have a short natal pelage at birth. Body weight is about 5.7 gm., head and body length 45 mm., tail 23 mm., head 18 mm., ear 4.5 mm., and pes 10 mm.

The eyes are closed with the junction of the lids appearing as a faint crease. The ear pinnae are erect but the apertures appear closed. The nose is short and broad with the mystacial region swollen and prominent. The front and back feet are evenly developed and lack obvious pigmentation. The tail is naked being white on the ventral surface but dark dorsally and only about half the length of the head and body. The skin is loose and wrinkled particularly on the hind legs. It is dark grey dorsally but white and semi-transparent ventrally. The pelage is longest on the dorsum, reaching to 2.5 mm. and of a grey colour. Ventrally it is white and slightly shorter.

A pair of incisor teeth have erupted in both jaws but no molar teeth are visible. The upper incisors are pale yellow on the anterior surface and clear the gums by about 0.5 mm. They are about 0.4 mm. wide, the interspace being about 1 mm. Each is slightly bicuspid and directed prominently inwards towards the throat. The lower pair are white and slightly longer and narrower than the upper, with the interspace being about twice the width of a single tooth. They are chisel pointed and like the upper pair, are set in a pronounced inward direction. This remarkable adaption was also fouud in the new-born young of *M. fuscus* (Calaby and Wimbush, 1964). Soon after birth the young fasten themselves to the inguinally-situated nipples with a tenaceous grip which make their removal by hand a difficult matter without incurring a risk of injury to the young or parent. When the young are so fastened, the parent may suddenly explode from the nest if alarmed and take sudden evasive action in the face of danger, while at the same time transporting the young with her by dragging them along between her hind legs. Rarely do young become accidentally dislodged under such stress and the grip has been found to be sufficiently strong, to permit the young from a few days old, to be carefully lifted until the full weight of the parent and remaining members of the litter are suspended in mid air. Such a grip is undoubtedly aided by the specially adapted incisor teeth. The habit of dragging the young provides a simple means of transport and probably reduces the predation of juveniles. A similar habit has been found to occur in *M. fuscus* (Calaby and Wimbnsh, 1964).

The newly-born young of *P. higginsi* spend much time sleeping in any position but usually upside down beneath the mother while still attached to the nipple. Periodic nervous twitching is eommon and breathing appears deep and forced. They possess good use of their legs and though blind, crawl about with ease. Squeaking noises are uttered when disturbed and are vigorous whenever the young feels pain. When removed from the nipples and held in the hand they nuzzle each other as if attempting to locate a nipple but if not roused will soon settle to sleep.

Growth and development

The following details of growth rate and development were compiled from the three litters of *P. higginsi* reared in captivity. Observations and measurements were made whenever opportunity permitted and were found to be fairly constant, falling closely within a well defined curve (see figures 8 and 9).

At birth the tail is shorter than the head and body length but it grows rapidly to equal the head and body at about 18 days and thereafter to exceed it. The pes also develops rapidly and almost trebles its length in the first five weeks to reach about 30 mm., which is near to that of adults. The rate of growth of the head and body, tail and pes are illustrated in figure 9 and progressive weight gain is shown in figure 8.

There was no significant differenee between the sexes as was found in *R. l. velutinus*. Weaning took place in the fourth week following which development continued unchecked. A gradual decline in the rate of growth and weight gain occurred in the autumn and during the winter months it almost ceased. At this time measurements were near the mean of all the wild eaught *P. higginsi* shown in table 9. An increase in the size and weight of the surviving young of the first litter was found to occur after the wiuter.

AT 8 DAYS (see plate 12) the young are capable of considerable activity and can crawl about the ground with confidenee but if undisturbed appear to spend most of their time asleep. The eyes are closed and the pinna of the ear is free though the aperture is swollen and appears closed. The incisor teeth retain their natal characteristics. The manus is white and the pes has a slight pale leaden hue. The fur on the dorsum is thick and the main pile has erupted at 1 mm. with guard hairs to 4 mm. Ventrally it is shorter and thinner. Mystacial vibrissae reach to 12 mm. The young do not maintain

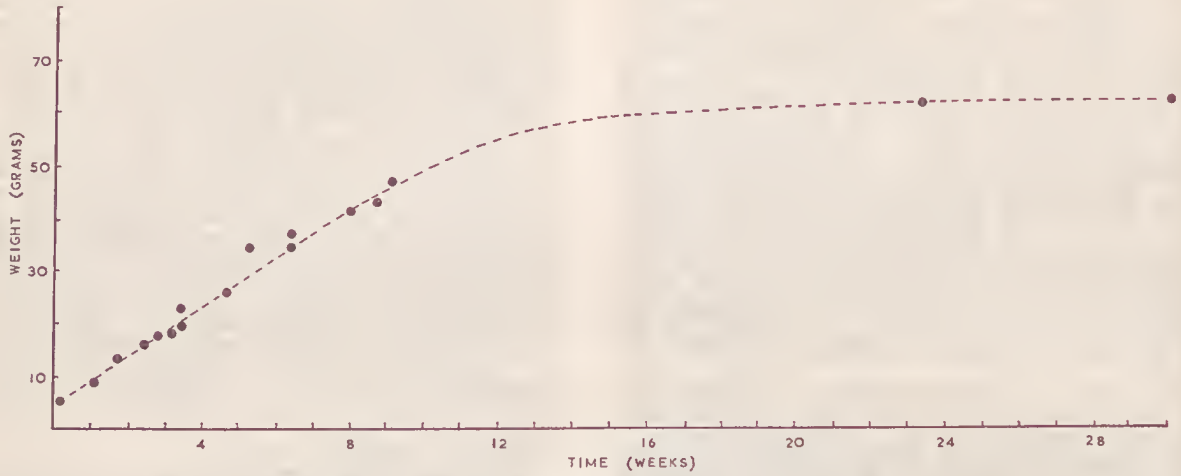

FIGURE 8. Rate of weight gain in the young of *P. higginsi*.

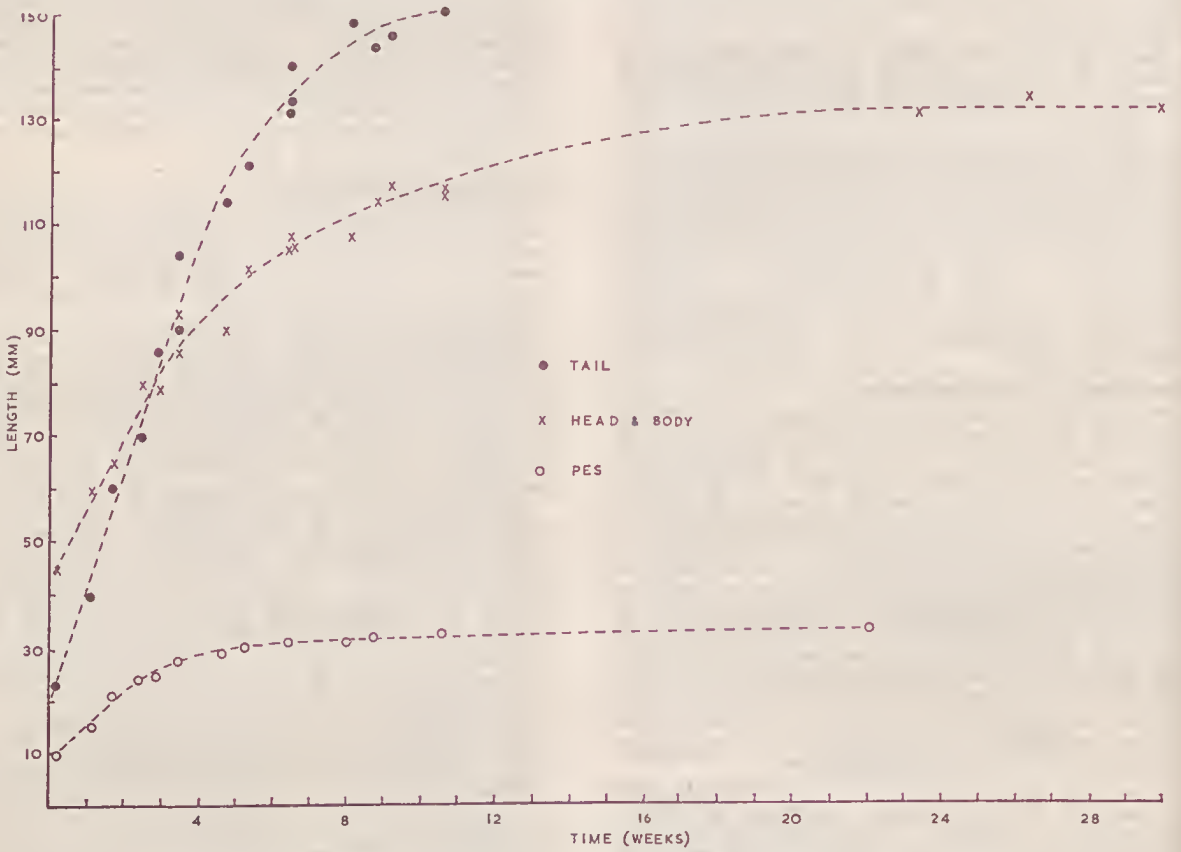

FIGURE 9. Rate of growth in the young of *P. higginsi*.

any suckling order, all nipples being sucked at various times, even if the litter is less than four.

AT 10 DAYS the young, though still blind, take active defensive action if disturbed in the nest when unattended. The slightest touch by the human hand, or any other object which may signify danger, results in a sudden explosion of activity. Lying on their backs the young vigorously beat the air with the feet as if in spiteful defence against anything which may come within reach. Interference with any young and its resultant activity usually triggers the rest of the litter to similar action. For some time afterwards they appear nervous and the return of the parent may momentarily produce such reaction. Recognition is quick and results in the young vigorously seeking and attaching to the nipples.

AT 12 DAYS the eyes are closed. The incisor teeth still retain the natal characters, the upper being erupted to 0.5 mm. and the lower to 1 mm. The main body pile on the dorsum has erupted to 4 mm. with guard hairs to 7 mm. and mystacial vibrissae to 15 mm. Ectoparasites may be present in the pelage.

AT 15 DAYS or thereabouts the eyes open.

AT 18 DAYS the young can run around actively, occasionally calling in a faint whisper-whistle but short sleeps are regularly taken when the opportunity permits. The basal region of the ears has lost its swollen appearance and the ears are functionally active. The incisor teeth retain their natal character and the young still fasten tenaciously to the nipple though at this age their grip is enlarged to include an area of skin and fur surrounding the nipple. If suddenly disturbed when unattached they immediately burrow beneath the parent's belly, turn over on their backs and use their feet to assist in locating the nipple. If the parent is prompted to run with the young attached they endeavour to run with her rather than be dragged as happens at an earlier age. The fur on the dorsum reaches to 6 mm. with guard hairs to 9 mm. Mystacial vibrissae reach to 25 mm. and are white except for the basal region which is dark.

AT 20 DAYS they still attach firmly to the mammary skin of the parent whenever she is in the nest. If alarmed when the parent is absent they are extremely active, often initiating escape action by sudden evasive leaps into the air in the same manner as the adults. The head looks proportionally large and the nose is broad. The dorsal fur reaches to 7 mm. and the guard hairs to 10 mm. Mystacial vibrissae reach to 29 mm. and extend in all directions. Washing is often carried out by the young rats licking the inside edges of the manus and rubbing them rapidly over the facial area.

AT 23 DAYS the young appear less dependent on the parent and are often content to sit beside her unattached. If alarmed they quickly seek a nipple and prepare for escape activity. The parent does not, at this stage, handle the young with her mouth but if one is removed from the nest she shows concern and often will step out to meet it and foster it back into the nest.

AT 25 DAYS (see plate 13) the young show considerable independence and when alarmed will often endeavour to escape by their own endeavours rather than seek the nipple of the parent.

They bite when handled though barely hard enough to puncture the skin of the hand. The incisor teeth have a yellowish anterior surface and are less incurved than at birth. The upper pair reach to 1 mm. and the lower to 4 mm. above the gums. Molar teeth have erupted. The dorsal pelage is a soft slate grey, the sandy yellow terminal band being much less extensive than in the adults. The ventral pelage is a very pale grey. The dorsal fur reaches to 9 mm. with the guard hairs to 15 mm. Mystacial vibrissae reach to 36 mm.

AT 33 DAYS the young are independent of the parent and have become weaned to a solid diet. The tips of the incisor teeth show normal wear and have assumed an adult-like appearance. The dorsal fur reaches to 10 mm. and guard hairs to 18 mm. The mystacial vibrissae reach to 45 mm. A slight dark pigmentation is present in the skin in the posterior scrotal region of males and small nipples can be found on the females.

AT 45 DAYS, except for their smaller size and more slate grey pelage, they are like adults in appearance and habits. The juvenile dorsal pelage remains at 10 mm. and guard hairs at 18 mm. but mystacial vibrissae have increased to 53 mm. The claws are long, well curved and sharp. They are active climbers, timid and alert.

AT 74 DAYS development of the scrotal region of males becomes noticeable, with the skin loose, hair prominent and the dark posterior pigmentation clearly evident.

Juvenile moult

The first moult begins when the young rats are about 50 days old. It starts on the flanks extending from the lower hind legs to the base of the ears and spreads towards the dorsum and ventrum.

AT 60 DAYS it has extended over the back where the new main pile reaches to 2 mm., onto the head and beneath the neck. It is not noticeable on the mid-belly.

AT 64 DAYS the new pelage on the flanks has advanced to 8 mm. but much of the old juvenile pelage still remains. On the mid-dorsal region it reaches to 5 mm.

AT 74 DAYS the new pelage on the flanks has outgrown the old juvenile pelage and reaches to 14 mm. On the mid-dorsum it reaches to 7 mm., and is still hidden by the juvenile pelage. Moult is evident in the region of the nose and lips.

AT 100 DAYS the moult is finished and the subadults have assumed an adult pelage.

TRAPPING AND FIELD STUDIES

Trapping

P. higginsi is readily trapped and is attracted by a variety of baits including bread, apple, raisins and a prepared mixture of rolled oats, honey, and peanut butter.

Both the common household snap-trap and Sherman box traps measuring 9 x 3 x 3 inches were used with success. About 10% of rats caught in snap traps suffered some degree of skull damage and about 30% of those taken in the Sherman traps suffered tail damage. *P. higginsi* was the only species in which this tail damage occurred. It resulted because of their relatively greater tail length and high susceptibility to tail slip. The terminal end of the tail was on occasions still outside the trap when the escape door was activated and so it became jammed. *R. l. velutinus, Antechinus swainsonii, Smithopsis leucopus* and *P. breviceps* were also taken in traps set for *P. higginsi,* the last mentioned, in a Sherman trap near Cradle Mountain on one occasion only. Predation on trapped rats was negligible. One

Sherman trap was crushed, apparently by the jaws of a devil *Sarcophilus harrisi* in its attempts to secure the bait or, more likely, a trapped animal. In some localities, particularly near Cradle Mountain, interference from brush possums *Trichosurus vulpecula* often resulted in sprung traps.

The selection of trapping sites was dependent principally upon the available ground cover. Wherever large decaying logs and dead stumps were plentiful or low growing vegetation was dense, traps were set at intervals of 10 to 20 yards. Selected sites were usually beneath some cover or near the entrance to a diurnal retreat if discernable. Success was variable according to the prevalence of animals but usually a 5% catch of *P. higginsi* could be expected. This would be supplemented by an additional 5% of other species. Because of susceptibility of *P. higginsi* to trapping, sets were not normally left more than one night in any area. This daily movement not only enhanced results but also reduced the possibility of local extermination.

Periodic checking of traps at different times of the day and night has indicated that *P. higginsi* is principally nocturnal. Rarely were catches recorded in daylight but they commenced soon after dusk and continued throughout the night. *P. higginsi* was never seen abroad in daylight and captive animals have shown a similar pattern of activity.

Field Studies

The trapping and release of tagged *P. higginsi* commenced near Cradle Mountain on 22.X.1965 in an area of dense myrtle *(Nothofagus)*—dominant rainforest. The floor was heavily littered with decaying logs and other forest debris and other cover was available in the form of low scrub. Forty trap sites were preselected and marked with numbered wooden pegs. They formed two roughly parallel lines about 40 yards apart, the traps being placed at intervals of about 20 yards. Where possible sites chosen were those which suggested the best results. Sherman traps were used and all animals captured were tagged in the posterior edge of the ear with fingerling fish tags. Trapping was carried out whenever opportunity permitted and to 4.VI.1966 eight *P. higginsi* were trapped, tagged and released in five visits. Of these, four were subsequently retrapped and released on five occasions. In addition, the area produced five *R. l. velutinus* on seven occasions, five *A. swainsonii*, none of which were retrapped and one *P. breviceps*, with a pouched young of 10 mm. crown-rump length. Difficulties were encountered, such as heavy winter snowfalls and interference to the traps by other mammals, which adversely effected the results of some visits. Possums were particularly troublesome as they persistently returned and sprung the traps in their endeavours to secure the bait. Results to date are too meagre to indicate any pattern of family groups. The greatest distance between points of tagging and recovery was about 100 yards with a time lapse of 41 days. Two other rats were recaptured over nearly similar distances and time lapse. The smallest rat to be tagged was of 33 gm. taken on 12.II.1966 at an estimated age of six weeks. The longest time lapse between tagging and recovery was 10 months for a male rat tagged outside the study area. It was captured beneath the ranger's house at "Waldheim" near Cradle Mountain on 27.VII.1966, having apparently been attracted there by pollard which had been stored as animal food. It was found freshly dead, as a result of having become jammed among plumbing supplies, at the place of tagging on 28.V.1967.

One female, tagged on 22.X.1965, was subsequently retrapped in a lactating condition on 2.XII.1965. It is intended to continue retrapping in the area as opportunity permits.

MISCELLANEOUS OBSERVATIONS

Keeping in captivity

P. higginsi is easily kept in captivity and despite its alert, nervous nature it has an inoffensive disposition and with a little care and attention can be easily handled. Wild-caught animals are prone to nervous, defensive squabbling if housed in confined quarters and will explode into a flurry of escape activity, leaping and climbing all over the cage at the slightest provocation. This nervousness is instinctive even in cage-bred animals and they may likewise be stimulated to such activity if upset. Newly wild-caught adults will gnaw in an attempt to escape but if provided with suitable housing they quickly settle to the new environment and may be kept in wooden cages without fear of escape by gnawing. A family group comprising several litters may be kept together in confined quarters without difficulty. Recognition of each other is strong and can occur even after a considerable period of separation, permitting immediate sharing of a common nest. Strangers are much slower to adapt themselves to each other's company and usually build separate nests which are occupied for some time before mutual tolerance is achieved.

Caged rats provided with sufficient dry grass or straw readily formed domed nests in the corner of the cage or within the seclusion of a nest box if such was available. Straw is shredded into fine fibrous strands by the rats passing the straw sideways between their teeth, feeding it through with their front feet while their incisor teeth bite in rapid succession. The treated material is then packed in the nest site and the action repeated until a sufficient accumulation has been formed.

Observations conducted with the aid of a spotlight on caged and wild rats has shown that activity is not unduly impeded by the artificial light. *P. higginsi* showed little concern from the presence and stealthy movements of *P. breviceps* but was usually nervous of *R. l. velutinus* and abandoned the feeding place when that species approached.

Diet, as discussed earlier, can include a wide variety of vegetable and invertebrate animal items. Water is taken when available but if absent, survival is possible provided sufficiently succulent food is provided.

Parasites

Ectoparasites have been collected whenever possible and lodged in the National Insect Collection, Canberra. Some recently collected material awaits determination but table 13 gives details of earlier samples together with additional material collected by B. C. Mollison. By far the most conspicuous parasite of *P. higginsi*

PLATE 8. Typical rainforest, the habitat of *P. higginsi*.

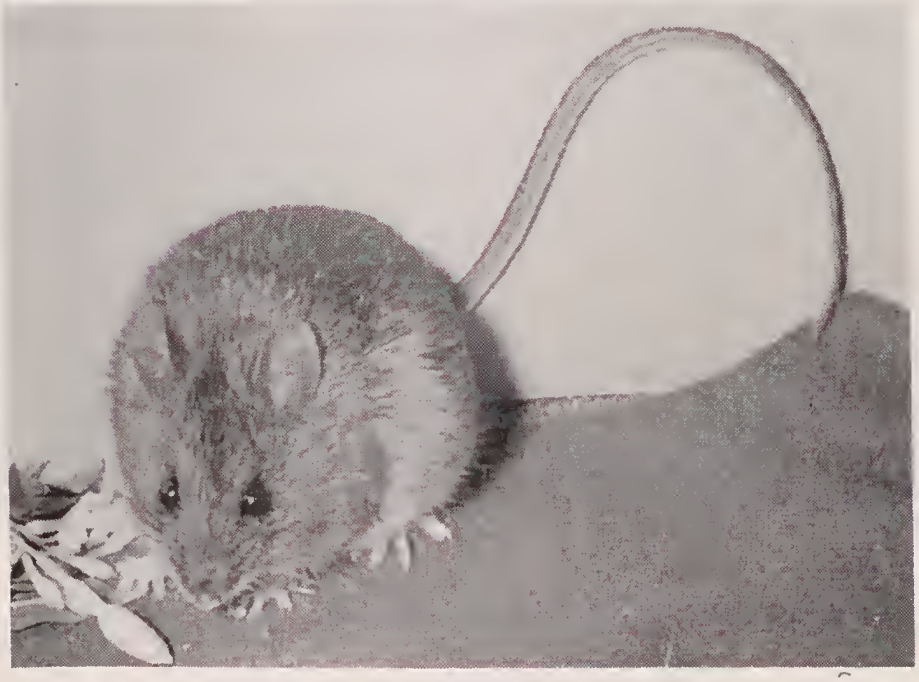

PLATE 9. Adult *P. higginsi*. Photo by H. J. King.

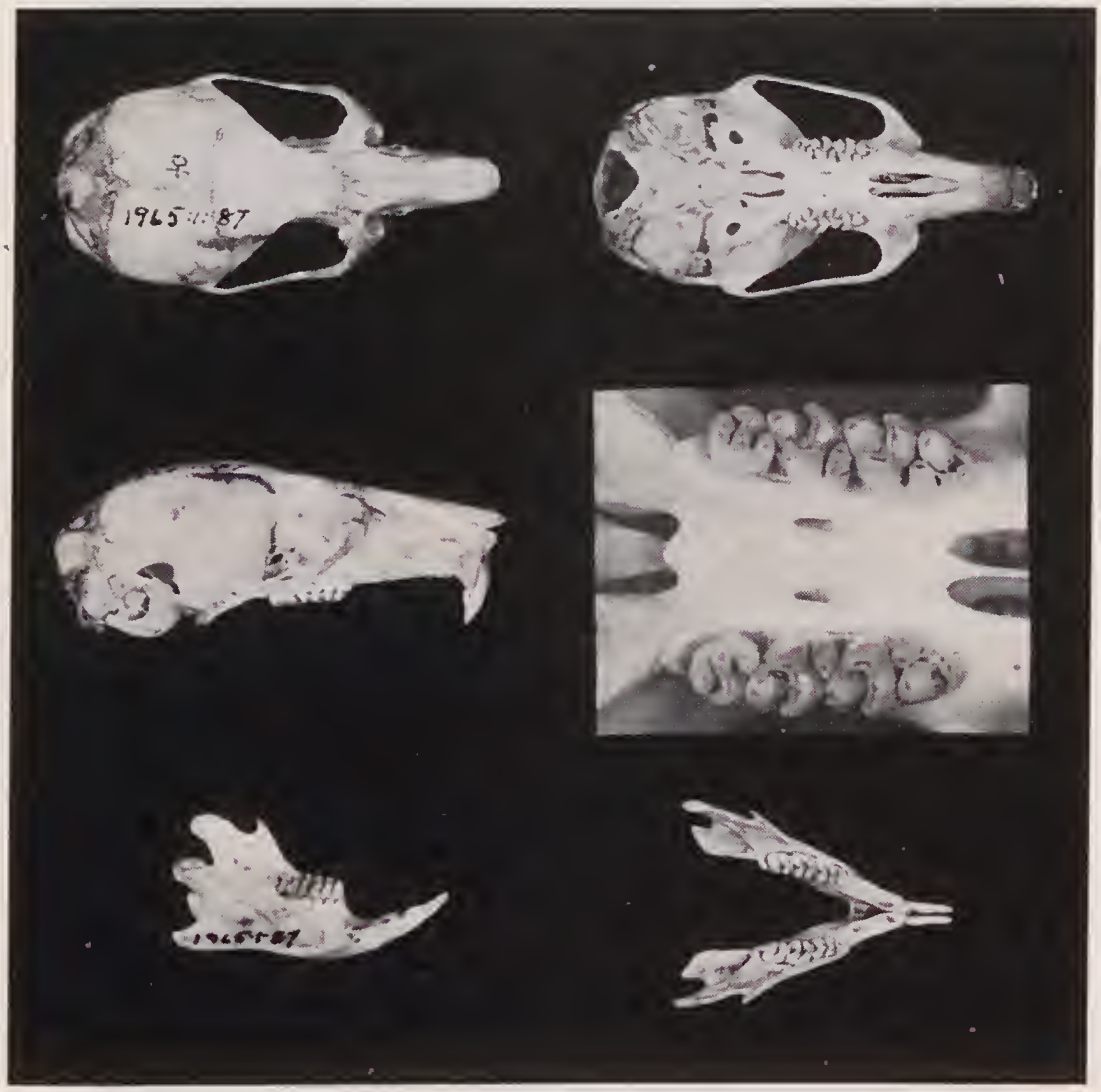

PLATE 10. Skull of a sub-adult *P. higginsi* with the molar teeth enlarged.

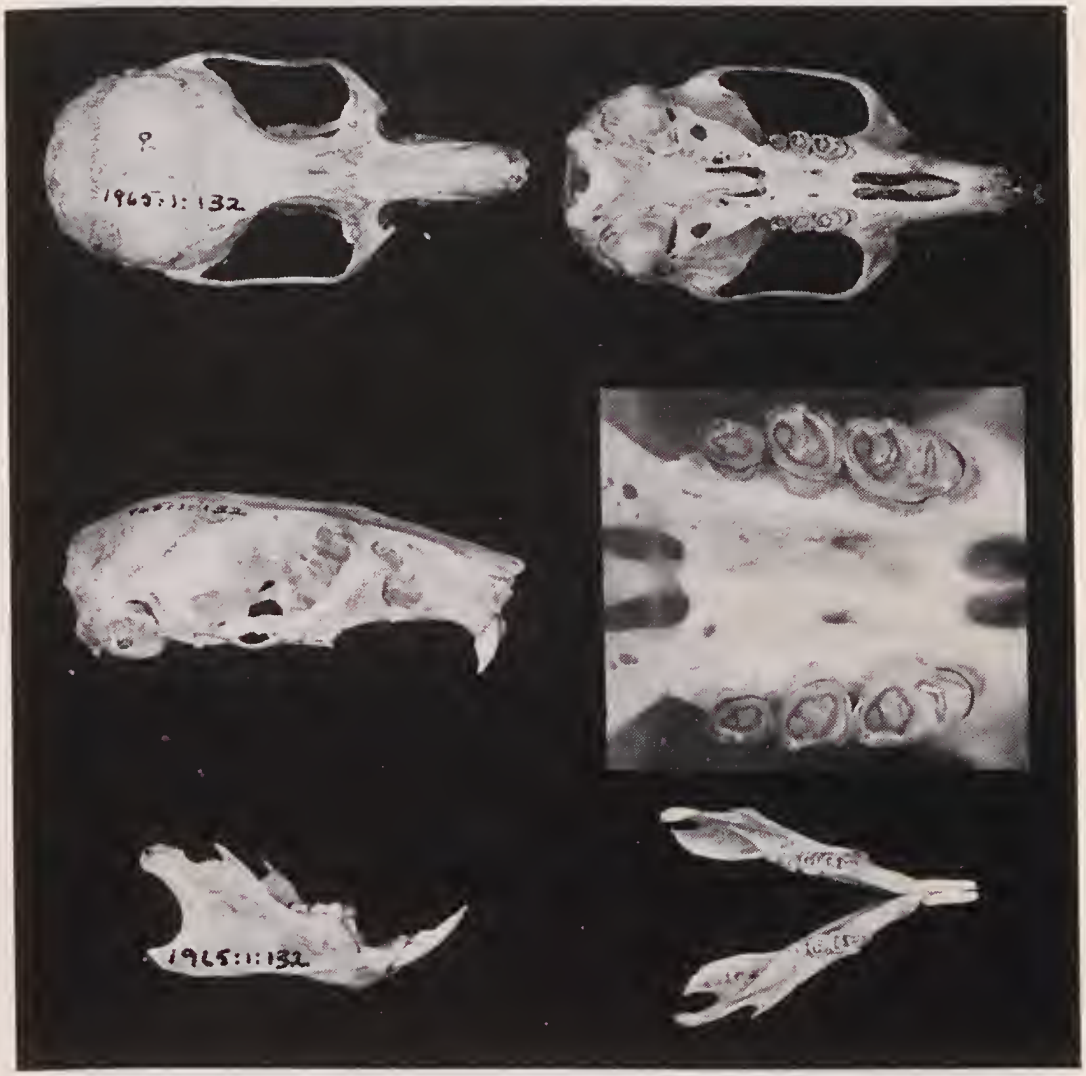

PLATE 11., Skull of an aged *P. higginsi* with the molar teeth enlarged to show the worn cusps.

PLATE 12. Female *P. higginsi* with young at 8 days old attached to the nipples.

PLATE 13. *P. higginsi* at 25 days old.

PLATE 14. View of the eastern shore of Lake Pedder looking northwest. *M. fuscus* occurs in this area. The location of the habitat illustrated in plate 15 is indicated by the cross. Photo by J. W. Thwaites.

PLATE 15. *M. fuscus* habitat on the eastern shore of Lake Pedder (see plate 14). Photo by J. W. Thwaites.

PLATE 16. Adult *M. fuscus*. Photo by H. J. King.

PLATE 17. An adult female *M. fuscus* showing the two pairs of inguinally positioned nipples.

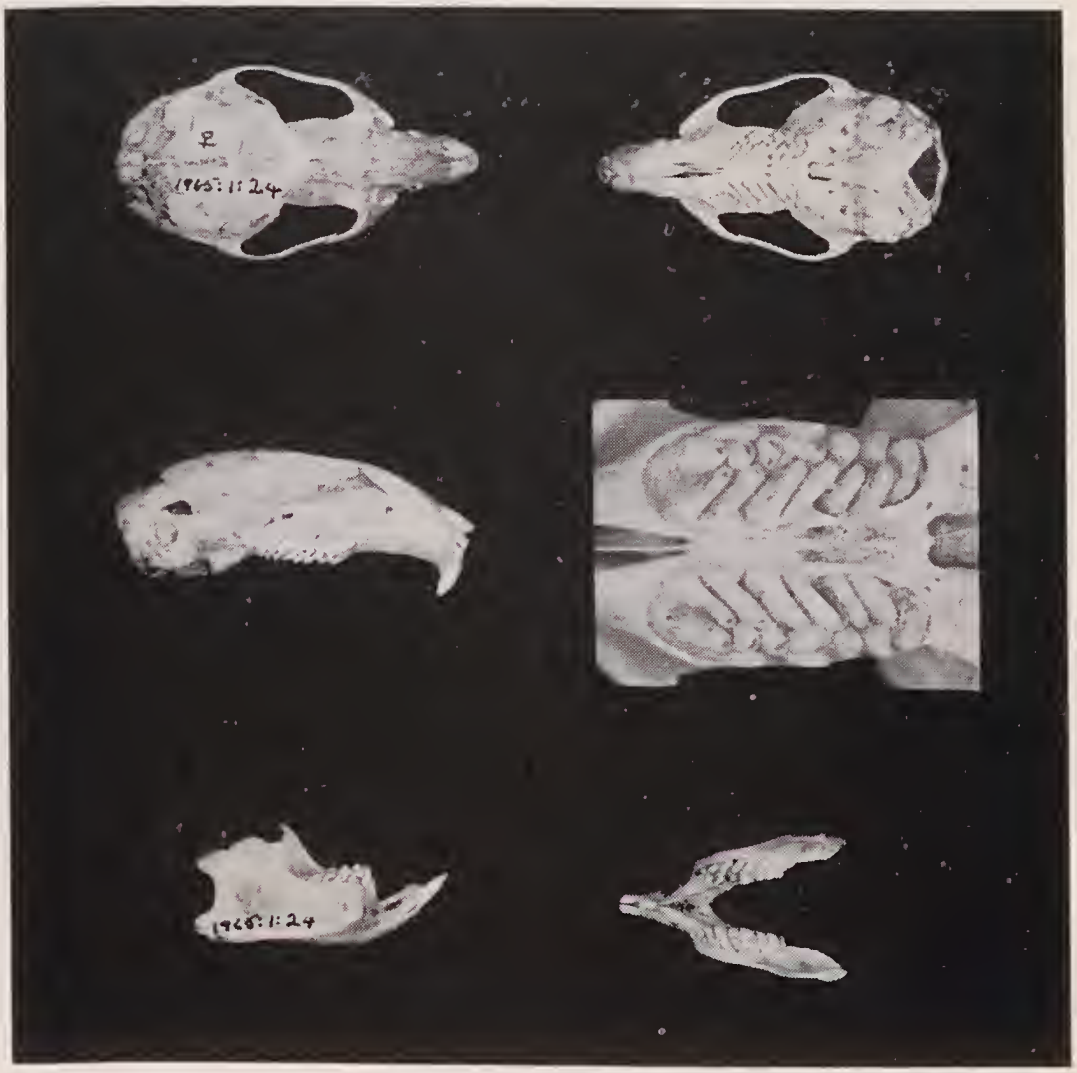

PLATE 18. Skull of sub-adult *M. fuscus* with the molar teeth enlarged to show the long cusps.

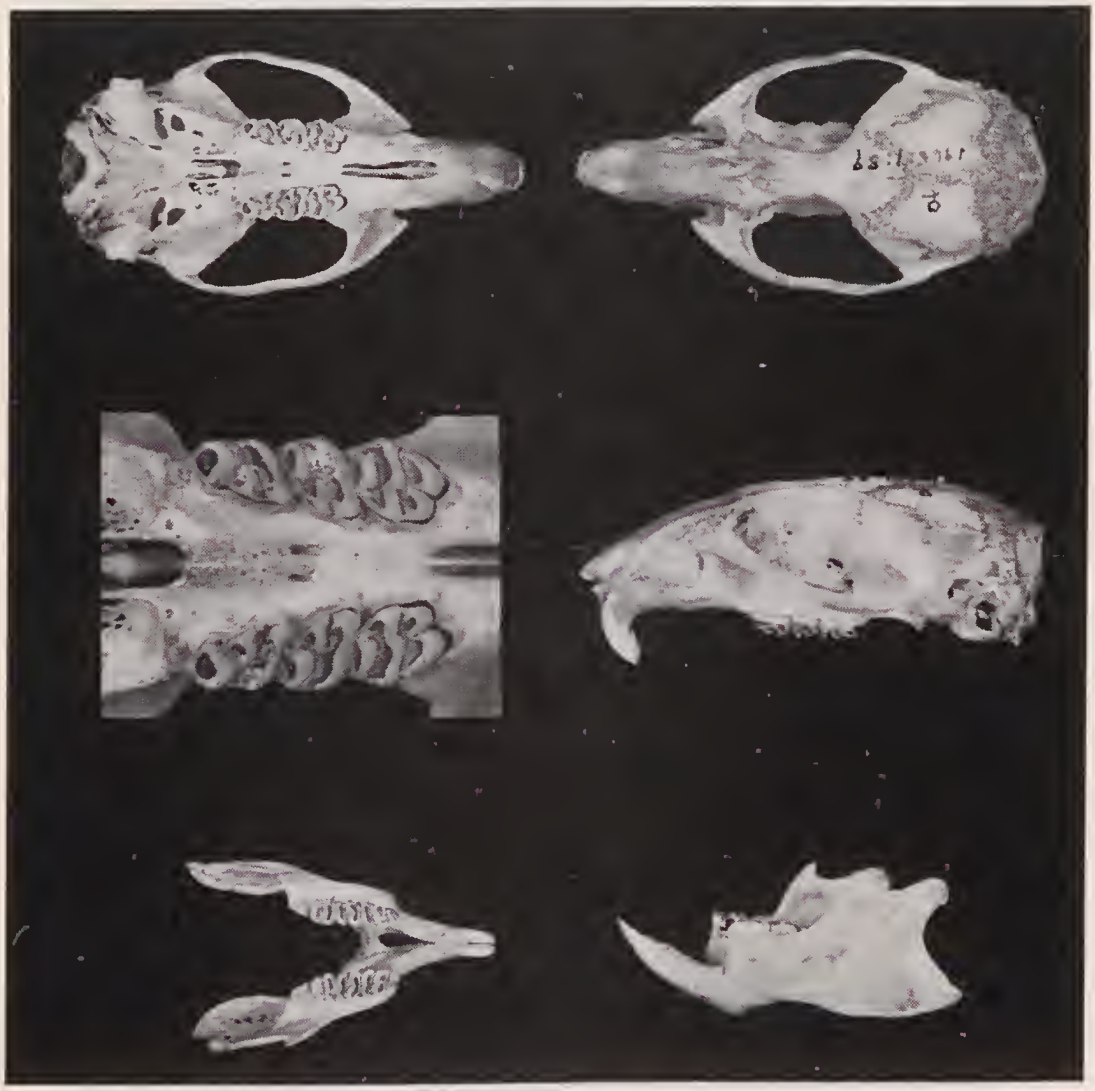

PLATE 19. Skull of an aged *M. fuscus* with the molars enlarged to show the worn cusps.

is the mite, *Laelaps calabyi*. It has been found in the fur on every occasion and occurred on suckling young 12 days old when the main pile of the pelage was 4 mm. long. No obvious skin damage, resulting from heavy tick infestation as was found in *R. l. velutinus*, has been encountered in *P. higginsi*.

The brains of seven *P. higginsi* were sent to the Department of Agriculture for inclusion in a survey of Toxoplasmosis in Tasmania and all produced negative results (Munday 1966). The lungs of three *P. higginsi* were examined by the same authority for *Emmonsia crescens*, also with negative results, but two were found to have small caseous abscesses and subacute interstitial pneumonia. One *P. higginsi* was examined for Leptospires in kidney sections, again with negative results (Munday 1966).

TABLE 13. Ectoparasites collected from *P. higginsi*.

ACARINA

TICKS (determined by Dr. F. H. S. Roberts)

Ixodes tasmani. Waratah, 27.VI.1963.

MITES (determined by Mr. R. Domrow)

Laelaps calabyi Mount Wellington at 4,000 feet; Arve Valley, December 1956; Port Davey, April 1962, September 1962; St. Valentines Peak, 3.VII.1962, Waratah, 7.VI.1963, 27.VI.1963, 30.VI.1963, 24.II.1964, Cradle Mountain, 4.X.1963, 7.X.1963, Renison Bell, 23.II.1964.

INSECTA

FLEAS (determined by Dr. G. M. Dunnet)

Pygiopsylla hoplia. Waratah, 24.II.1964.

Acanthopsylla rothschildi. St. Valentines Peak, 13.VII.1962.

A. sp. Waratah, 24.II.1964.

Stephanocircus pectinipes. Waratah, 7.VI.1963.

LICE (determined by Dr. Theresa Clay)

Hoplopleura calabyi. Waratah, 7.VI.1963, 24.II.1964, Cradle Mountain, 7.X.1963.

Natural enemies

Much of the rainforest in which *P. higginsi* occurs is relatively free of avian and mammalian predators as these animals prefer to hunt in the marginal and less densely forested areas. No doubt the masked owl *Tyto castanops* and quoll *Dasyurus viverrinus* exercise a control in the ecotonal habitat but they normally shun dense rainforest free from roads, tracks and nearby clearings.

Trapping has produced *R. l. velutinus* and *A. swainsonii* wherever *P. higginsi* has been found and it is possible that both these animals exercise some measure of population control on *P. higginsi*. When *R. l. velutinus* and *P. higginsi* adults were experimentally housed together in a confined cage the former was found to have killed and partly eaten the latter on the first night. When housed together in the large cage previously described, *P. higginsi* was always found to evade contact with *R. l. velutinus* whenever possible and the death of two sub-adults and tail damage to the remaining three is indicative of interspecific combat.

A. swainsonii has been found to take mice and small birds (unpub. data) and no doubt would be capable of taking the young of *P. higginsi*. The defensive actions of the unattended juveniles of *P. higginsi*, as described earlier, also suggests some form of predation upon the young. *R. l. velutinus* and *A. swainsonii* are the most likely offenders, though the rarer *S. leucopus* would play a similar role wherever it occurs. The present population of *P. higginsi* in its preferred habitat indicates that predation is not excessive and merely serves to maintain a healthy balance.

Habitat destruction by fire occurs at periodic intervals and to varying degrees but as it has been part of the forest ecology since long before the invasion of European man and is less extensive since the extinction of the aborigines (Jackson 1965) it is not envisaged as a threat to the species. Extensive timber milling is taking place in some localities and this temporarily disrupts or locally annihilates the small mammals. Regrowth is usually rapid and permits repopulation within a reasonable period. As the rain forest extends over a great part of Tasmania, mostly in remote and relatively inaccessible semi-mountainous terrain I see no reason why *P. higginsi* should not continue to flourish within these limits.

Part 4. *Mastacomys fuscus* Thomas

ABSTRACT

The results of three years' (1963-1965) collecting and field observations on the broad-toothed rat *M. fuscus* are recorded.

The known local populations from which specimens have been collected are given and the possible extent of distribution is mapped.

A full description based on 58 specimens collected in Tasmania is given, together with tabulated measurements of plastic features and skulls.

The Victorian sub-species *M. f. brazenori* which was separated from the Tasmanian nominate subspecies on relative tail length is not substantiated on an assessment of the figures provided by this larger series.

Notes are given on habits and the rat's restriction to a very limited habitat type. Diet and the peculiar characteristics of faecal pellets are described.

Breeding has been found to be seasonal, extending from about October to March with two being the usual litter, though more than one litter may be produced annually. Some details are given of embryonic features and their development.

A series of ectoparasites has been collected and some determinations are tabulated.

The influence of natural predation and the effect of future mineral and industrial development and land utilization within the range of its known distribution is discussed.

DISTRIBUTION

Since the inception of this survey in 1963 (see part 1, Introduction) the known range of *M. fuscus* in Tasmania has been extended (see map, fig. 10) to include other areas near Cradle Mountain, Waratah and Lake Pedder. It has now been collected from altitudes ranging from near sea level at Port Davey (see part 1) to about 3,000 feet near Cradle Mountain. Cradle Mountain is within the boundaries of a proclaimed fauna sanctuary from which no specimens may legally be removed. All specimens recorded from there were taken outside the sanctuary boundary.

All populations have been found to be very localized and confined to a limited habitat type. Though they might occur in many places through the area indicated on the distributiou map, the individual occurrences are generally isolated and difficult to locate. Trapping in the north and east of the island has failed to produce *M. fuscus*. The possible distribution range indicated on the map (fig. 10) is based on the few known relict populations and on the extent of range of the preferred habitat in which the rats may be expected to occur. Within this range there are large areas of dense rainforest broken up by wet sedgelands which occur as forest openings (Jackson 1965). It is within the vicinity of the drainage systems of these sedgelands that *M. fuscus* has been found.

The presence of *M. fuscus* material in a deposit of regurgitated pellets of the masked owl *Tyto castanops*, found in a cave near Granton, indicates the presence in recent years of a nearby population as the remains were contemporary with those of introduced rats and starlings (B. C. Mollison pers. comm.).

A once wider distribution is evident from the presence of fragmentary skull remains in bone deposits in the Flowery Gully limestone caves, a series of which is held in the collections of the Queen Victoria Museum.

FIGURE 10.
Localities from which *M. fuscus* has been collected and the possible distributional range based on habitat. Places mentioned in the text are: 1. Cradle Mountain, 2. Waratah, 3. Lake Pedder, 4. Port Davey, 5. Flowery Gully, 6. Granton.

HABITAT

Unlike *Rattus lutreolus*, *M. fuscus* appears to have been unable to adapt itself to a diversified environment and it is now limited to small areas of preferred habitat (Calaby and Wimbush 1964). Collecting in Tasmania has revealed a strong preference for swampy ground which during the winter months may be semi-inundated, though it may dry out in the summer. Its range covers an area of little agricultural or pastoral importance which is periodically subjected to uncontrolled fires. This in turn also limits the area of occupiable habitat as regeneration is slow, and it may take five to ten years before a suitable cover is attained. In Tasmania all the known populations occur in areas of *Mesomelaena sphaerocephala* (button grass) or in various adjacent ecotone habitats. *M. fuscus* invariably occurs in association with *R. l. velutinus* and *Antechinus m. minimus*, all three species sharing the same labyrinth of runways which are formed among the dense vegetation.

Near Cradle Mountain a population survives in an ecotone dominated by *Poa caespitosa* (tussock grass) through which is distributed *Caloraphus lateriflorus* (spreading rope-rush), *Restio australis* (mountain cord-rush) and *Lepidosperma filiforme* (common rapier-sedge) (see part 1, plate 1). This is on steeply sloping ground which for much of the year is waterlogged with drainage from the more elevated areas of myrtle rainforest. Another population was discovered living in an extensive sphagnum moss bog. Burrows were formed in the moss which, at maximum, was several feet in depth. The area was in a small valley and was heavily waterlogged for most of the year. Other populations were found on the banks of small streams where the cover included such additional plants as *Sprengelia incarnata* (swamp heath), *Epacris gunnii* (Gunn's heath), *Baeckea gunniana* (shrubby heath-myrtle), *Monotoca sp.* (broom

heath), *Boronia rhomboidea* (diamond boronia) and *Leptospermum* sp. (tea-tree).

Throughout this sub-alpine habitat the winter climate is severe with air temperatures falling as low as 10°F. Extensive snowfalls annually envelop the area for weeks at a time (see part 2, plate 2) and, though not heavy enough to compress the sheltering vegetation, it does confine *M. fuscus* and associated small mammals to very limited areas by blocking the exposed parts of runways extending across clear ground. Examination of areas under such conditions gives the impression that the rats do not leave the shelter and protection afforded by the snow-covered vegetation, but remain within the confined areas until the thaw permits a return to their normal range. Calaby and Wimbush (1964) found a somewhat similar winter condition in the Whites River area in the Kosciusko State Park, but whereas there the porous nature of the soil renders post-thaw flooding negligible, the reverse is the case in Tasmania and surface water continues to drain away until well after the thaw. Summer temperature may reach as high as 90°F and the mean annual rainfall is about 100 inches.

Finlayson (1933) gives an account of the habitat in which he collected *M. fuscus* at Cradle Mountain. The exact location from which the two Port Davey specimens (Tasmania Museum Reg. ZC 41) were collected is not recorded but except for altitudinal and coastal influences, most of the habitat is basically similar over a great deal of the western part of the island.

In February 1967 the Queen Victoria Museum combined with the Tasmanian Museum to undertake a zoological survey in the vicinity of Lake Pedder. The area under study (see plates 14 and 15) is at an altitude of about 950 feet and the habitat is typical of much of the western highlands. Small mammal trapping, undertaken by J. W. Swift, resulted in the capture of two *M. fuscus* (Reg. Nos. 1967.13 and 16). They were taken in areas about 10 miles apart and separated by a stretch of the Serpentine Valley. This area is heavily waterlogged for the greater part of the year, and only in mid-summer does it dry out to any extent. *R. l. velutinus* and *A. m. minimus* were also collected in the same habitat, as they were in other known *M. fuscus* localities. Lack of time and the nature of the country prevented detailed sampling but the impression gained was that *M. fuscus* occurs extensively though perhaps patchily through the drainage systems of the area.

DESCRIPTION

Descriptions of the pelage and plastic characters of *M. fuscus* based on mainland Australian specimens are given by Brazenor (1936) and Warneke (1960). Thomas (1882) based the original description on a single specimen and Finlayson (1933) amplified this description following the collecting of five specimens near Cradle Mountain. The present description is based on a series of 54 skins and associated skulls and four spirit specimens held in the Queen Victoria Museum. They have been assembled in the course of field studies conducted in the above mentioned areas of the western highlands.

External characters

In general form *M. fuscus* is a stout, thick-set rat (see plate 16) with a strong superficial resemblance to *R. lutreolus* for which it has, on occasions, been temporarily mistaken (Warneke 1960).

The ears are well rounded and appear almost naked but under magnification are found to be clothed on the exposed parts with short, fine sandy-brown hairs which vary in density between individuals. The facial region is more plump and rounded than that of *R. l. velutinus*, the cheeks noticeably more full and the eyes larger and more prominent. The iris is deep brown and the pupils black. The nostrils are naked and a pale flesh pink colour. The incisors are yellow on the anterior surface, the upper set being considerably darker. Both upper and lower incisors wear to chisel points the acuteness of which varies between animals. The lower incisors reach to about 7.5 mm. above the gums on their labial surface which is about twice the overall width of the pair in their mid region. This feature is a useful character in distinguishing live *M. fuscus* from *R. l. velutinus* in which the lower incisors reach to 10 mm. and are exposed for a length of about three times their overall width.

The legs are short and the feet stout with the upper surface sparsely covered with short silvery-grey hairs. A few longer hairs on the extremities of the toes may extend beyond the ends of the claws. The claws are strong, well curved and of a white colour though a faint grey pigmentation is often visible beneath the semi-transparent surface. The under surface of the feet is somewhat variable but the manus is always paler than the pes. The manus is usually a dirty white but may have some pale leaden marking particularly beneath the toes, while the pes is usually a pale leaden-grey over most of its surface. The pads of the feet are smooth and vary slightly in shape between individual rats. In the manus the three interdigitals are approximately equal in size while the two metacarpals are very much larger and more prominent. The digital formula is $3 > 4 > 2 > 5 > 1$, the first being greatly reduced. There are usually four digital rings beneath each toe but in some instances a weakly formed fifth ring is present at the base of the toe.

In the pes the inner metatarsal pad is generally the largest and the outer the smallest with four interdigitals being intermediate. However the inner metatarsal of *M. fuscus* is not as large and is less elongated than that of *R. l. velutinus* though in relative proportions the pes of *M. fuscus* is noticeably longer. This is amply illustrated by Finlayson (1933). The digital formula is $3 > 4 > 2 > 5 > 1$ though the difference between 2, 3 and 4 is very slight. There are usually four digital rings beneath the first toe and five to six beneath the other four which is in excess of the number found in *R. l. velutinus*.

The tail is shorter than the head and body, stout and gently tapered with leaden-grey scales arranged in about 120 irregular rings. Near the base of the tail the scales number about 20 each ring but near the tip they decrease to about ten. The tail is sparsely covered with bristle-like hairs which are generally a dark grey colour though some, particularly the shorter ones and those on the ventral surface, may lack pigmentation. In the mid-region of the tail they are arranged in groups of three, erupt from behind each scale and are directed anteriorly. On the distal portion they become reduced in numbers but near the base they may increase to 6 in a group. They vary greatly in length but may reach to 3 mm., more than double those of *R. l. velutinus*, a feature which gives them a softer appearance.

The nipples number four and are situated inguinally, as in all pseudomyine rats. (See plate 17). The scrotum becomes prominent with maturity and the approach of the breeding season when it may measure up to 40 x 25 mm. and contain testes of 25 x 15 mm. It is well furred except for the posterior region which is naked and darkly pigmented.

Pelage

No sexual dimorphism is noticeable in the pelage. The fur is soft, slightly more so than in *R. l. velutinus*,

dense, and in fully-furred rats reaches to 20 mm. over the dorsal region, reducing to 10 mm. on the head and ventral region. The guard hairs are prominent on the dorsum, are black for their entire length and well tapered. They are longest on the rump where they may reach to 30 mm. On the ventrum they are nearly similar to the main pile.

The body pile is a soft leaden-grey being slightly paler on the ventral surface. The terminal region is a sandy-yellow on the dorsum, in some instances with the extreme tip black. On the ventrum this terminal region merges to a very pale grey. The overall composite effect varies slightly between individual rats and is dependent on the prevalence of the guard hairs. In some instances these are hardly noticeable and these rats have a slightly more sandy appearance. As mentioned by Finlayson (1933), the composite effect varies with the angle of viewing.

Plastic dimensions

Plastic measurements were taken as described for *R. l. velutinus* (see part 2). Table 14 is based on a series of 37 rats comprising 20 males and 17 females. All rats of a body weight of less than 100 gm. have been excluded.

The heaviest rat collected was a male taken in the month of June which had a body weight of 196 gm. and a total length of 305 mm. with a head and body length of 195 mm. By comparison the heaviest female was taken in February and in heavy lactation. She weighed 158 gm., was 299 mm. in total length, and had a head and body length of 170 mm. The heaviest pregnant female was also taken in February and weighed 150 gm. She carried two embryos developed to 35 mm. crown rump length. This is considerably less than that recorded by Calaby and Wimbush (1964) for a captive rat which attained a body weight of 173 gm. prior to parturition. The lightest male was collected on 11.II.1965 and was a sub-adult of 53 gms. The lightest female was collected on 21.II.1965 and was a sub-adult of 45 gms.

The length of the tail, ear and pes when expressed as a percentage of the head and body length (see table 15) gives an indication of the relative proportions of animals but indicates no significant sexual dimorphism.

Ride (1956) using dimensions provided by Brazenor, separates the Victorian form as *M. f. brazenori* from the nominate Tasmanian form on the relative lengths of the tails when expressed as a percentage of the head and body length. Ride submits that the tails of *M. f. brazenori* average 73% while those of *M. f. fuscus* average 64% for animals of similar general size. Calaby and Wimbush (1964) found all other modern mainland Australian *Mastacomys* material inseparable from Ride's *M. f. brazenori*. They list a small series from Loch Valley (measured by Warneke) in which the tail averages 74% and a series of six near adults from near White's River in which the tail averages 71.3% of the head and body length (range 68.2—75%). The distinction between *M. f. fuscus* and *M. f. brazenori* based on the relative tail length is not supported by my examination of the nominate sub-species as the figures given in table 10 fall within the range of those given by others for the mainland Australian form. This discrepancy in results obtained by different authors is probably due to different methods of measuring the tail.

Skull

The measurements given in table 16 were made on a series of 36 skulls and were taken in the same manner as illustrated in part 2. Skulls of rats of a body weight of less than 100 gm. have been excluded. Because of skull damage caused by trapping it was not possible to measure every feature in each instance and accordingly the number on which measurements were made is recorded for each feature. No sexual dimorphism is indicated in skull proportions.

Tooth wear varies greatly within the series. Sub-adults at about 50 gm. exhibit very little wear, the molar cusps being long and well defined. (See plate 18). Those of the upper set are strongly arched posteriorly particularly in the anterior member in which the angle is about 45 degrees. Those of the lower set are sloped anteriorly with the posterior member bearing the more prominent slope. Some rats with a body weight in excess of 100 gm. had very little molar wear, while in others molar wear was advanced (see plate 19) though in no instance was it found to be excessive. Annual grouping based on the degree of molar wear as illustrated in *R. l. velutinus* (see part 2, plate 5) was not possible and such wear appears to be slower and less pronounced in *M. fuscus*. This, in turn, suggests a somewhat longer life span.

Lower incisors are usually tapered by wear on the posterior surface to a fine chisel-like cutting edge, though in one instance they were found to be strongly notched apparently as a result of abnormal contact with the upper set. Except for this, no case of malformation or decay was evident.

A detailed description of the skull is given by Finlayson (1933).

HABITS

Runways

M. fuscus has been found principally in wet, swampy areas. Its occurrence is usually associated with well worn runways as described for *R. l. velutinus* (see part 2 of this series) but as no habitats are known in which *R. l. velutinus* is not also present, it is difficult to say what part *M. fuscus* plays in the formation and maintenance of runways. The runways in known *M. fuscus* habitat are identical to those in areas where only *R. l. velutinus* occurs but as both animals are so nearly similar in size and habits this is to be expected and it can fairly be assumed that both species are responsible for their formation. *M. fuscus* has been trapped on well-used runways which are virtually under water or on which the surface has become muddy by the action of the rats' feet. It appears to favour such conditions preferring them to those of the better drained areas of somewhat similar vegetational cover in the same vicinity. It does not vacate its established range when this dries out during the summer months.

No known nests of *M. fuscus* have been found but it is assumed that they are placed in the dense clumps of button grass or tussock grass in the same manner as those of *R. l. velutinus* (see part 2). It has never been found in subterranean burrows and its preferred habitat is quite unsuitable for burrowing.

M. fuscus is diurnally active and a sub-adult was seen feeding in an exposed situation about mid-day. Numerous individuals have been trapped during the hours of daylight.

Feeding and faeces

Though *M. fuscus* has been found to take a variety of foods in captivity (see later), its normal diet in a wild state appears to be purely vegetarian and of a very limited range. The stomach contents generally appear of an even greenish mealy nature and only in one instance was it found otherwise. This was in an animal taken at Lake Pedder in mid-February, in which the stomach contents were of a reddish-brown colour. A microscopic examination of stomach

TABLE 14. Weight (gm.) and measurements (mm.) of 37 *M. fuscus* with a body weight of 100 gm. or more. Quotations are for extremes with the mean shown in brackets.

	20 Males	17 Females
Weight	100 - 196 (136.2)	106 - 158 (134.2)
Total length	255 - 310 (278.5)	261 - 299 (279.8)
Tail	102 - 135 (115.2)	109 - 129 (117.4)
Head and body	147 - 195 (162.8)	147 - 182 (163.1)
Ear	20 - 23 (21.4)	20 - 22 (20.9)
Pes	31 - 35 (32.8)	31 - 35 (32.5)

TABLE 15. Length of tail, ear and pes of 37 *M. fuscus* of a body weight of 100 gm. or more expressed as a percentage of the head and body length.

	20 Males	17 Females
Tail	70.8	72.0
Ear	13.2	12.8
Pes	20.1	19.9

TABLE 16. Comparisons (in mm.) of skull measurements of males and females of *M. fuscus* with a body weight of 100 gm. or more.

	17 Males			19 Females		
	No. Sampled	Range	Mean	No. Sampled	Range	Mean
1. Total length	13	38.1 - 44.2	40.5	16	37.4 - 42.5	40.2
2. Condylo-basal length	13	35.5 - 41.9	38.3	17	36.6 - 39.8	37.9
3. Basal length	13	32.9 - 39.0	35.6	17	32.6 - 37.2	35.0
4. Zygomatic width	13	21.2 - 23.4	22.1	14	20.7 - 23.1	22.2
5. Inter-orbital width	14	3.6 - 4.2	3.9	18	3.6 - 4.3	3.9
6. Inter-parietal length	14	4.7 - 6.9	5.8	16	4.5 - 5.9	5.4
7. Inter-parietal width	14	9.3 - 11.0	10.2	16	9.7 - 12.0	10.7
8. Cranium width	14	15.9 - 17.5	16.9	16	16.4 - 17.8	17.2
9. Mastoid width	13	15.9 - 17.8	16.8	16	15.4 - 17.5	16.7
10. Nasal length	17	14.1 - 16.7	15.7	18	14.5 - 17.1	16.0
11. Nasal width	17	4.0 - 4.9	4.4	19	4.2 - 4.8	4.4
12. Palatal length	15	20.3 - 25.9	22.8	19	21.3 - 24.2	22.7
13. Palatal foramen length	16	6.7 - 9.7	7.6	19	7.2 - 8.3	7.7
14. Palatal foramen width	15	1.4 - 2.0	1.7	19	1.3 - 2.2	1.6
15. Width inside M^1-M^1	15	1.3 - 2.2	1.8	19	1.4 - 2.4	1.9
16. Width outside M^1-M^1	13	8.5 - 9.4	8.8	19	8.5 - 9.5	9.0
17. Bulla length	17	5.1 - 6.3	5.7	17	5.7 - 6.7	6.1
18. Length crowns M^1-M^3	17	7.3 - 9.0	8.2	19	8.0 - 9.3	8.5
19. Length alveoli M^1-M^3	17	9.2 - 10.9	9.9	19	8.8 - 10.5	9.7
20. Length crowns M^1-M^2	17	4.9 - 6.0	5.3	19	4.7 - 5.8	5.4

contents of several animals revealed the contents to be finely comminuted and to consist mainly of common rapier-sedge with the addition of a small quantity of leafy tissue from a small-leafed dicotyledon, and fragments of a very finely-stemmed grass. Fragments of sphagnum moss have been found in stomachs and teeth but is not believed to be a favoured food. There was a complete absence of insect fragments in the sample microscopically examined, and all other samples examined with the naked eye have failed to suggest anything but a purely vegetarian diet.

The sap of rapier-sedge is rich in green pigmentation and if chewed, readily produces a bright green juice. This colouration is prominent in the faeces of *M. fuscus* and serves to distinguish it from *R. l. velutinus* which produces faecal pellets of a brown or greyish colour. The faeces of the latter species are also drier and less finely comminuted. *M. fuscus* defaecates and urinates indiscriminately and its presence can often be predicted by a scattering of the characteristically soft green faecal pellets along the runways.

BREEDING

In the wild

The testes of sub-adult males are not descended during the rats' first summer and even in sub-adult animals up to 90 gm. in weight collected in February no scrotal development had taken place and the testes measured about 7 mm. by 4 mm. In the following spring, with the approach of the breeding season, the scrotum develops to about 40 mm. by 25 mm., the testes enlarge to about 25 mm. by 15 mm. and are then carried low in the scrotum.

Seven females have been trapped in a pregnant condition (see table 17), the earliest seasonal record being for a rat in early pregnancy taken on 5.X.1963 and the latest on 20.II.1965 with two embryos of 17 mm. crown-rump length carried in the left horn of the uterus. Her nipple condition indicated recent lactation and the right uterine horn possessed three prominent placental scars. All of the pregnant females were carrying two embryos, though Calaby and Wimbush (1964) record litters of one, two and three. The evidence shows that the breeding season is in summer and extends from October to March, with each female producing more than one litter annually. Calaby and Wimbush (1964) record three litters from a captive animal over the period December 21 to March 10.

TABLE 17. Analysis of seven sets of embryos from wild caught *M. fuscus*. Those marked with * were too premature to measure.

Date	Crown-rump length (mm.)	Number	Uterine horn	
			Left	Right
5.X.1963	*	2	1	1
5.X.1963	*	2	Not	recorded
6.X.1963	*	2	2	0
9.II.1965	28	2	1	1
11.II.1965	33	2	2	0
20.II.1965	14	2	2	0
21.II.1965	75	2	1	1

In captivity

Attempts to breed *M. fuscus* in 1964-5, in small cages as described in part 2, failed. Because of loss of the breeding stock no attempts were made under the more roomy conditions which were found to produce the spectacular breeding success in *R. l. velutinus*. Breeding in captivity has been successfully achieved by the C.S.I.R.O. Division of Wildlife Research and some results are given by Calaby and Wimbush (1964).

Description of embryos

At a crown-rump length of 7 mm. the embryo is contained within an approximately spherical sac about 12 mm. in diameter. It lacks obvious detail except for the eye which appears as a tiny circle of dark pigment. The tail reaches to about 4 mm. and is finely tapered; the fore and hind limbs are mere buds of about equal proportions and the head and neck region is almost half of the total body mass. The neck is strongly arched to such extent that the facial region is almost between the hind feet and is overlaid by the tail.

At a crown-rump of 14 mm. the embryo is contained within a sac about 17 mm. in diameter. The eye appears as a darkly pigmented ring, the ears and facial features are obvious, the mouth is well formed and can be easily opened and the tongue is prominent and free moving. The tail reaches to 5 mm., the feet are prominent and the toes well splayed. The neck is less arched and the chin rests between the front feet with the tail just reaching the nose. The head and neck region are almost half the total body mass.

At a crown-rump length of 28 mm. the sac has developed an elongated appearance, reaching to 30 mm. long and 15 mm. in diameter. The eyes no longer appear as dark rings, the lids being obvious and about 2 mm. wide. The facial features are prominent and the posterior members of the mystacial vibrissae have erupted to about 1 mm. Wrinkling occurs in the skin, the tail tapers to 11 mm., the feet are well formed with the pads obvious and the vagina and anus appear to be open. The head is about 35 per cent of the total body mass, the nose carried down at right angles to the body where it rests forward of the front feet.

At a crown-rump length of 33 mm. the embryo closely resembles that of the 28 mm. embryo. The tail tapers to 12 mm. and the pes is 7.5 mm. The ear pinna is free but folded down over the ear opening. Except for the mystacial vibrissae there is no evidence of pelage eruption or of the presence of teeth.

Calaby and Wimbush (1964) give the following measurements of a new born young: head and body 63 mm., tail 24 mm., hind foot 13.4 mm., and the ear 5 mm. They also give measurements of a litter of slightly lesser proportions. They describe the pelage as developed to 4 mm. in the mid dorsal region, mystacial vibrissae up to 8 mm. and the presence of

two pairs of colourless incisor teeth which project about ½ mm. They also give an account of growth and development of young in captivity and describe the adaptation of the incisor teeth which enables the young to maintain a grip of the teat while being dragged around by the parent. This adaptation is apparently similar to that occurring in the endemic Tasmanian pseudo-rat *P. higginsi* (see part 3).

TRAPPING AND FIELD STUDIES

Trapping

The study of *M. fuscus* has been undertaken in conjunction with that of *R. l. velutinus* and the same methods, equipment and decoy baits, as described in part 2, have been used for both species. The apparently limited vegetarian diet of *M. fuscus* makes it a more difficult rat to trap as there appears to be little attraction to all of the baits used to date. Trapping with Sherman traps in known *M. fuscus* populations has resulted in negative catches where a subsequent trapping in the same area with snap traps has produced good results. Many of such catches have been made as a result of the rat running across the trap and not by its taking the bait. Consequently, rats have on occasions been caught by the foot or tail. Almost all catches were made on well-defined runways with the trap set in such a position that the rat runs into it during its normal progression. Trap checking at various times of the day has shown *M. fuscus* to be diurnally active, with dusk visits often producing the best results. Trapping in any one area was normally limited to a 24 hour period not only to enhance the catch but also to safeguard against local extermination.

Field Studies

A field study of a tagged population was commenced near Cradle Mountain on 22.X.1965. The area selected was vegetated principally with poa tussock-grass and was on a steeply sloping bank. Previous examination had confirmed the presence of a considerable *M. fuscus* population. Trapping was carried out in a rectangular grid pattern with 40 Sherman traps dispersed over an area of about 150 yards by 75 yards, and a variety of baits were tried. On the initial set the only animals caught were three adult *M. fuscus*. They were tagged with fingerling fish tags, weighed, and various other details recorded before release. On 4.XII.1965 two additional *M. fuscus* were trapped and similarly tagged. From the commencement of the field study to 17.X.1966, seven trapping excursions were made to the area but no *M. fuscus* was ever recaptured, though the presence of the species was obvious from the condition of faecal pellets on the runways. Three additional small mammal species were also trapped in the study area over this period. Thirteen *R. l. velutinus* were taken on 55 occasions, 10 *A. swainsonii* on 15 occasions and 3 *A. minimus* on 3 occasions. The failure of the *M. fuscus* study is believed to be a direct result of their selective feeding habits and their consequent reluctance to enter the Sherman traps as the baits offered were not sufficiently attractive.

Occasional bait sampling or curiosity apparently accounts for an odd catch but successful live trapping seems dependent on the use of a run-through trap or one activated by the animal passing along its runway as no known bait offers a sufficient lure to entice *M. fuscus* into box type traps in satisfactory numbers.

MISCELLANEOUS OBSERVATIONS

Keeping in captivity

M. fuscus has a docile nature, particularly the males. Wild-caught animals will quickly become accustomed to handling and show little fear of humans. When the individuals which were tagged and handled in the study area were released they moved slowly away without haste or obvious fear. One climbed across an observer's boot and smelt around the vicinity of the equipment for about half a minute before moving away along a runway. Individuals retained for cage studies took food items from the hand when these were presented through the wire of the cage, within a few minutes of capture. Animals kept and hand-fed in small cages soon became so quiet that when they were released in an enclosed room they were recaptured with no difficulty. One such male was released for several minutes in natural bush where it disappeared beneath the thick vegetation. On reappearance it was again picked up without difficulty. It will feed on a variety of vegetable foods when no alternative is available, but apple, bread, lawn clippings, and commercial dog cubes have formed the main diet of caged individuals. Water is taken liberally if available but experiments and field observations have shown that *M. fuscus*, like *R. l. velutinus* (see part 2), is capable of surviving over dry periods without free water, provided it can obtain reasonably succulent food.

Parasites

Ectoparasites have been collected from *M. fuscus* whenever possible and lodged with the National Insect Collection, Canberra. Some determinations are given in table 18 together with an earlier sample from Port Davey. No abnormally heavy infestations of ectoparasites or obvious endoparasites have been noted.

Lice taken from *M. fuscus* which were collected at Mt. Kate, near Cradle Mountain on 6.X.1963, have been described by Kuhn and Ludwig (1966) as a new species, *Hoplopleura mastacomydis*. This louse has also been collected from *M. fuscus* in New South Wales.

TABLE 18. Ectoparasites collected from *M. fuscus*.

ACARINA
TICKS (determined by Dr. F. H. S. Roberts)
Ixodes tasmani. Cradle Mt., 5.X.1963 (nymph), 8.XII.1963 (nymph).
MITES (determined by Mr. R. Domrow)
Laelaps cybiala. Port Davey, 1951; Cradle Mt., 26.IV.1963, 5-7.VI.1963, 4-6.X.1963, 8.XII.1963.
INSECTA
FLEAS (determined by Dr. G. M. Dunnet)
Pygiopsylla hoplia, Cradle Mt., 26.IV.1963, 5-6.X.1963.
Macropsylla hercules. Waratah, 6.VI.1963.
LICE (determined by Dr. Hans-Jürg Kuhn)
Hoplopleura mastacomydis. Mt. Kate (near Cradle Mt.) 6.X.1963; Cradle Mt. 26.IV.1963.

The brains and lungs of one *M. fuscus* were sent to the Department of Agriculture for inclusion in a survey of the occurrence in Tasmania of Toxoplasmosis and *Emmonsia crescens*. The results were negative (Munday 1966).

Natural enemies

No evidence has been found to suggest excessive predator pressure on *M. fuscus*. Its normally close association with *R. l. velutinus* no doubt renders it liable to predation suffered by that species which in the past appears to have assisted in the maintenance of a healthy balance (see part 2). The Quoll *D.*

viverrinus, is not uncommon over much of the range of *M. fuscus* and no doubt it takes this rat, along with other small mammals. Extensive Quoll padding which was found following an overnight snowfall on an area of known *M. fuscus* occurrence near Cradle Mountain (see part 2) is indicative of Quoll predation. The finding in the area of the broken remains of a skull and limb bones of *M. fuscus* was consistent with what may be expected from Quolls.

The marsupial mouse *A. m. minimus* invariably occurs in the same habitat and in association with *M. fuscus*, and *A. s. swainsonii* may similarly be encountered in ecotone areas bordering rain forest. Both these ravenous little carnivores may be expected to take young rats if the opportunity offers. The feral cat is uncommon in *M. fuscus* habitat. The greatest factor limiting the population of *M. fuscus* appears to be the availability of suitable habitat. Though there are many suitably swampy drainage areas in the western half of Tasmania, much is uninhabitable because post-burn regrowth is not sufficiently advanced to provide good cover. Fire has always been a factor in the maintenance of the open sedgelands (Jackson 1965) but at the same time such fires often remove areas of habitat on which *M. fuscus* depends for survival.

Summer cattle grazing also destroys some habitat. During this normally dry season cattle congregate around the watering places and greener areas and often these are also the habitat of *M. fuscus*. Consequently the severe trampling in cattle camps, together with the grazing, renders such areas unsuitable for *M. fuscus*.

Though the range of *M. fuscus* is included in an extensive area of Tasmania which is still relatively inaccessible to man, it must be remembered that because of the very limited nature of its preferred and rather specialised habitat, populations occur in only relatively small and semi-isolated areas within this range. With the large scale mineral and hydro development now taking place in western Tasmania and the provision of access roads, man's influence on the long unaltered environment is becoming increasingly evident. Extension of cattle grazing and the flooding of valleys for future hydro development will, in many cases, be removing forever some of the best *M. fuscus* habitat. The threat to its survival as seen by Calaby (1963) is increasing with state development and the small areas occupied by colonies, by their very nature, are likely to suffer in various ways as an effect of man's increasing penetration of western Tasmania.

The future of this little-known mammal is indeed threatened and its extinction can only be prevented by the preservation of large tracts of suitable wilderness, before the onrush of development brings a premature end to another interesting species.

REFERENCES

BRAZENOR, C. W. (1936): Muridae recorded from Victoria. Mem. Nat. Mus. Vict., No. 10, pp. 62-85.

CALABY, J. H. (1963): Australia's threatened mammals. *Wildlife* (Brisbane), Vol. 1, pp. 15-18.

CALABY, J. H. and WIMBUSH, D. J. (1964): Observations on the Broad-toothed Rat, *Mastacomys fuscus*. *C.S.I.R.O., Wildlife Research*. Vol. 9, No. 2, pp. 123-133.

FINLAYSON, H. H. (1933): On *Mastacomys fuscus*. Thomas. Trans. Roy. Soc. S. Aust., Vol. 57, pp. 125-129.

JACKSON, W. D. (1965): Vegetation. pp. 30-35. *Atlas of Tasmania* (J. L. Davies) Lands and Survey Dept., Hobart.

KUHN, H. J. and LUDWIG (1966): Ann. Mag. of Nat. Hist., Ser. 13, Vol. IX., pp. 657-674.

MUNDAY, B. L. (1966): Diseases of Tasmania's free-living animals. *Tas. Dept. Agric. Research Bulletin*. No. 5.

RIDE, W. D. L. (1956): A new fossil *Mastacomys* (Muridae) and a revision of the genus. *Proc. Zool. Soc. Lond.*, Vol. 127, pp. 431-439.

THOMAS, O. (1882): On two new Muridae from Tasmania. *Ann. Mag. Nat. Hist.*, Ser. 5, Vol. IX, pp. 413-416.

WARNEKE, R. M. (1960): Rediscovery of the Broad-toothed Rat in Gippsland. *Vict. Nat.* Vol. 77. No. 7, pp. 195-196.

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